AERONAUTICAL ENGINEERING REVIEW

JANUARY 1949

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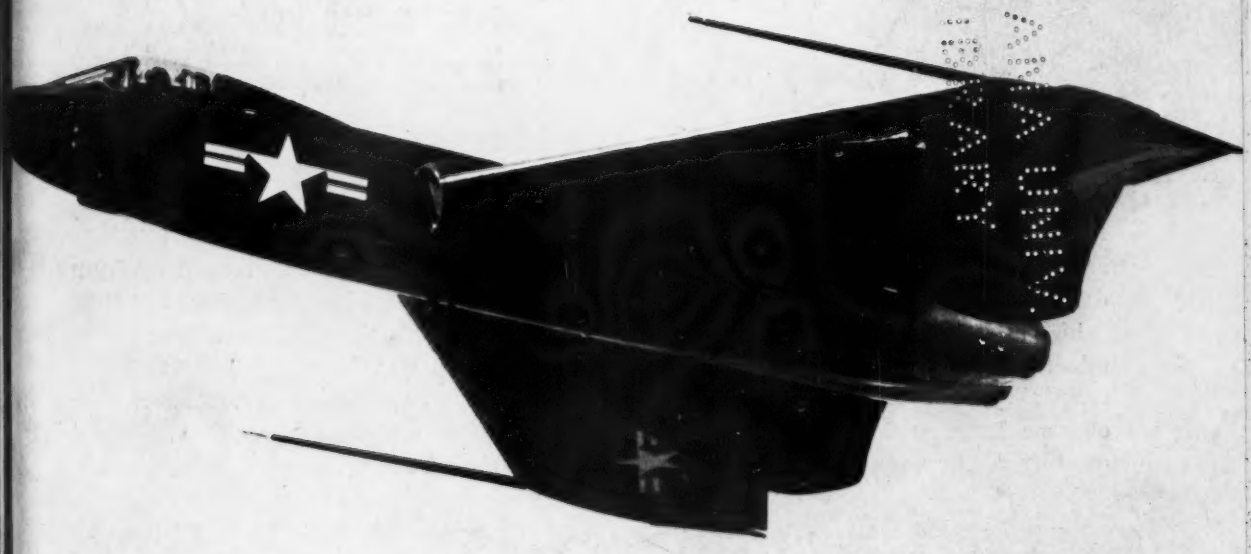

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...has a FEATHER-WEIGHT in its "Cool-Tank"

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Inside Story

of Stratocruiser's Range

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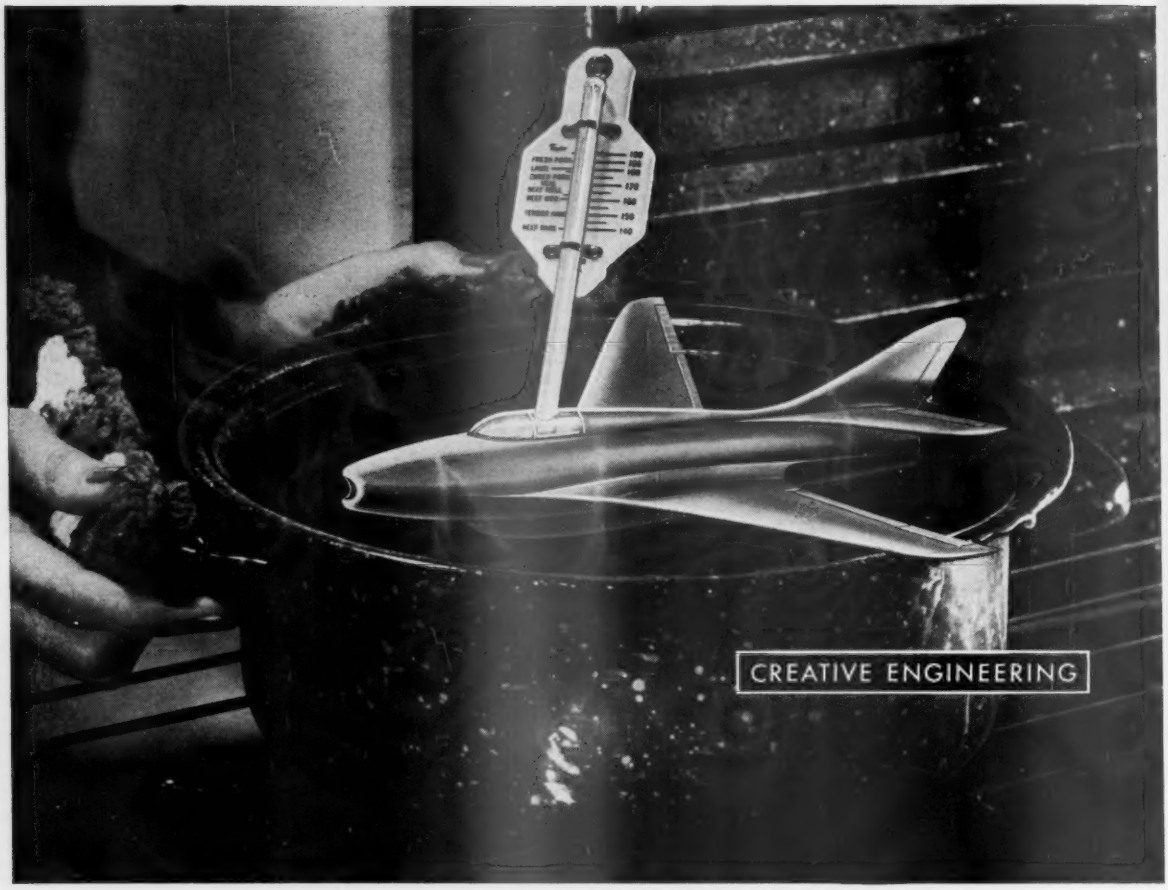

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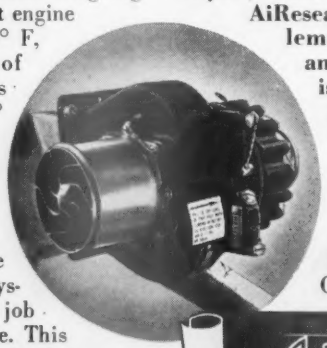

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Cover—Navy's new Chance Vought XF7U-1 swept-wing twin-jet fighter.

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Contents

I.A.S. News 5

Editorial 19

Articles

General Fairchild on "Air Force Headquarters Policy" 20

Psychological Aspects of Stick and Rudder Controls in Aircraft . . . . . Jesse Orlansky 22

Application of Servo Systems to Aircraft . . . . . John R. Moore 32

I.A.S. Briefs 45

Reviews

Aeronautical Reviews 47

Books 73

Personnel Opportunities 87

Index to Advertisers 91

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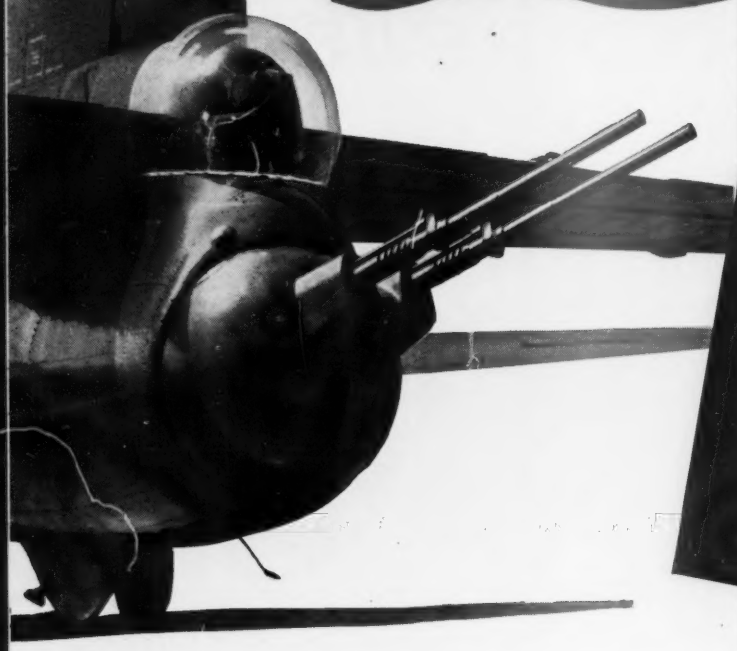

The Navy's Lockheed P2V

USE

VICKERS HYDRAULIC TRANSMISSION

The Emerson Electric Mfg. Co. tail turret for the Navy's long range patrol bomber, Lockheed P2V's, is powered by a Vickers hydraulic transmission. This equipment comprises the power transmission and associated controls of the servo circuit. Accuracy and rapidity of response are fundamental characteristics of this Vickers equipment because of the extremely low inertia of rotating parts. The two separate hydraulic motors for train and elevation of the turret are individually and completely controllable in direction of rotation and speed by the application of a few milliamps of signal current.

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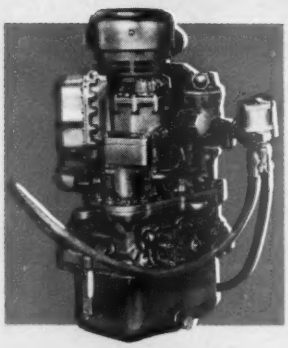

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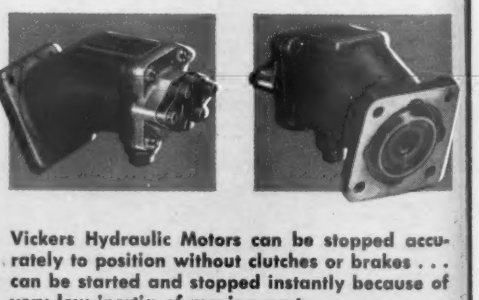

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

I.A.S. News

A Record of People and Events of Interest to Institute Members

Burden Named 1949 President Succeeding Northrop

I.A.S. Council Also Elects J. L. Atwood, C. J. McCarthy, G. S. Schairer, and Elmer A. Sperry, Jr., New Vice-Presidents; Earl D. Osborn, Treasurer.

WILLIAM A. M. BURDEN, former Assistant Secretary of Commerce for Air, was elected seventeenth President of the Institute of the Aeronautical Sciences by the I.A.S. Council. He will be formally inducted into office at the Honors Night Dinner, January 24, at the Hotel Astor in New York City. Mr. Burden is presently Specialist in Aviation, Smith, Barney & Company, New York City.

In addition to electing the new 1949 I.A.S. President, the Council named the new slate of Vice-Presidents and new Treasurer for the coming year.

▸ **New Officers**—The 1949 Vice-Presidents include: J. L. Atwood, a Fellow and First Vice-President, North American Aviation, Inc.; C. J. McCarthy, a Fellow and Vice-President, United Aircraft Corporation; G. S. Schairer, Member and Staff Engineer, Boeing Airplane Company, Seattle; and Elmer A. Sperry, Jr., Fellow and Vice-President and Treasurer, Sperry Products, Inc.

The 1949 Treasurer is Earl D. Osborn, Associate Member and President of Edo Corporation. Mr. Osborn was a 1948 Vice-President.

▸ **In Aviation 20 Years**—Mr. Burden, who first was connected with aviation in 1928 in charge of Analysis of Aviation Financing for Brown Brothers, Harriman & Comany, has since had a wide experience in aeronautical matters both in this country and abroad, in Government service, and private interests.

In 1932–1939 he was in charge of Aviation Research, preparing basic surveys on air transportation and the manufacturing industries in Europe, Far East, and South America for Scudder, Stevens & Clark of New York. He then was named Vice-President and Director of National Aviation Corporation and Director of United Airlines Transport Corporation in 1939–1941.

▸ **Helped Oust Axis in S.A.**—As Vice-President, Defense Supplies Corporation (subsidiary of the R.F.C.), Washington, D.C., Mr. Burden was in charge of the Division of American Republics Aviation and was active in eliminating Axis influence in Latin America from 1941–1942.

In 1942, he was named Special Aviation Assistant to the Secretary of Commerce with supervision of the Civil Aeronautics Administration, Weather Bureau, and Coast & Geodetic Survey, and in 1943 President Roosevelt made him Assistant Secretary of Commerce for Air.

In addition, Mr. Burden served as U.S. Delegate to the International Civil Aviation Conference held in November, 1944, and was Chairman, U.S. Delegation, First Interim Assembly, Provisional International Civil Aviation Organization, Montreal, 2 years later. He resigned as Assistant Secretary of Commerce for Air in 1947.

Elected I.A.S. President: *William A. M. Burden has been named 1949 President of the Institute, formally taking office at the coming Honors Night Dinner, January 24.*

▸ **Donates Air Library**—In 1940 Mr. Burden donated to the Institute the most complete privately owned collection of aeronautical publications, photographs, clippings, and reports known in this country, which formed the basis of the Aeronautical Archives.

National Meetings Calendar

January 24–27	Seventeenth Annual Meeting, New York
March 18	Fourth Annual Flight Propulsion Meeting, Cleveland

Military Aeronautics Meeting at Dayton Hears General Fairchild

THE I.A.S.-AIR MATERIEL COMMAND held its joint Military Aeronautics Meeting at Dayton, November 18 and 19, winding up with a flight-line static display and flight demonstrations at Wright-Patterson Air Force Base. More than 200 of America's best designers of military aircraft, together with leading officers of the Air Force, were present, including Gen. Muir S. Fairchild, Vice Chief of Staff, U.S.A.F., who was the principal speaker at the banquet given at the Biltmore Hotel on the evening of the opening day.

▶ **Event Broadcast**—The meeting was picked up by the American Broadcasting Company network during the banquet with I.A.S. Director S. Paul Johnston querying Generals Fairchild and B. W. Chidlaw (Deputy Commanding General, A.M.C.), Mundy I. Peale, President, Republic Aviation Corporation, and Lt. Col. David Schilling, former commanding officer of the famed 56th Fighter Group, Eighth Air Force, as to present capabilities of the Air Force in meeting any situation that might arise.

Later, in the lobby of the Victory Theater, where the world première of the Warner Brothers picture, *Fighter Squadron*, was held, at which the I.A.S. was one of the guests of honor, a second broadcast was made.

▶ **Papers Given**—On the opening day of the meeting, five papers were delivered by A.M.C. personnel. Among those giving the talks were Major Gen. F. O. Carroll, Director, Research & Development; C. E. Reichert, Chief, Design Branch, Aircraft Laboratory; Lt. Col. J. H. Carter, Chief, Guided Missiles Section, Engineering Operations; and Col. R. T. Wassell, Assistant Chief, Power Plant Laboratory.

The following day, the meeting was addressed by Lt. Col. E. N. Ljunggren, Chief, Aircraft Operations, Aircraft Laboratory; Col. J. F. Taylor, Chief, All Weather Flying Division; and Col. H. M. McCoy, Chief of Intelligence, A.M.C.

▶ **Aid by Dayton Section**—The program was prepared by the Air Materiel Command in cooperation with the I.A.S. Dayton Section led by Chairman A. A. Arnhym. Lieutenant Colonel Arnhym also was one of the distinguished group who offered opening remarks at the first day of the meeting.

Two Inventors: *Igor I. Sikorsky (left), Engineering Manager, Sikorsky Aircraft, who developed the Sikorsky line of helicopters, talking with Lt. Col. Albert A. Arnhym, Chief of Air Documents Division, A.M.C., and Chairman of I.A.S. Dayton Section. Colonel Arnhym, who holds numerous patents on aircraft accessories and electronic devices, also invented the radio-light phone.*

Other officers of the Dayton Section are A. F. Arcier, Vice-Chairman; A. B. Deyarmond, Treasurer; Major W. A. Barden, Corresponding Secretary; and Lt. R. Crawford, Recording Secretary.

I.A.S. Military Aeronautics Dinner Speaker: *Gen. Muir S. Fairchild (left), Vice Chief of Staff, U.S.A.F., addresses guests at the I.A.S. dinner in the Biltmore Hotel, Dayton, November 18, on the subject of Air Force headquarters policy. Seated at speaker's table are (left to right) John K. Northrop, I.A.S. 1948 President, and Gen. B. W. Chidlaw, Deputy Commanding General, Air Materiel Command. (Right) An Air Materiel Command speaker at one of the technical sessions of the joint I.A.S.-A.M.C. Military Aeronautics Meeting in Dayton strikes a responsive chord in his listeners as he delivers a paper on aeronautical research. In the audience were S. Paul Johnston (left), Director of the Institute, and Major Gen. Frank O. Carroll, Director, Research & Development, A.M.C.*

14 Divisions Affected in S.A.I.S. Coordination Work

Coordination work by the Standard Aeronautical Indexing System staff affecting 14 divisions of the system was discussed at a conference held at I.A.S. headquarters in New York recently.

▸ **Section Headings Established**—Section headings were established at the conference for Divisions No. 24, Military Aviation (revised title for "Operations Military"); No. 29, Navigation; No. 30, Meteorology; No. 34, Rotating Wing Aircraft; No. 36, Production; No. 47, Reference Works and Literature; No. 46, Organizations and Societies; and No. 14, Machine Elements.

On the basis of widespread coordination, it was decided to separate Division 37, Personnel, into two divisions—one, "Industrial Relations" and the other, "Education and Training." Former retains No. 37, but no number has been assigned as yet to the latter.

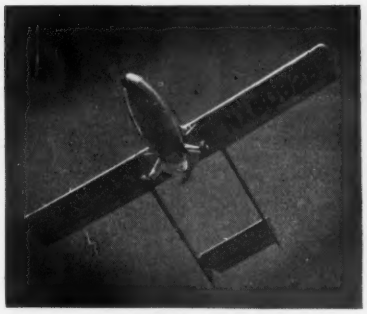
▸ **Deletions Made**—Recommendations that several of the existing tentative divisions be deleted were accepted, since their subject matter was provided for in other divisions already established. Among those omitted were No. 27, Installations, Ground; No. 28, Installations, Shipborne, and No. 43, Air Power, all of which are covered in the section breakdown of No. 24, Military Aviation.

Division No. 38, Standards & Specifications, was eliminated because the subject is covered in a large number of existing divisions, and what material remains may be covered under Reference Works & Literature, No. 47, and Engineering Practices & Aids, No. 49.

In order to effect these changes with a minimum of disturbance to Air Technical Index distribution program, it was decided to defer the assignment of a division number to "Education & Training" and the utilization of the numbers left blank by the deletions of the other divisions until the next coordination conference.

▸ **Direct Headings**—Among other subjects considered was the form of the division headings, some of which are now inverted. S.A.I.S. staff study resulted in a recommendation that direct headings be used in most cases. Results of this research will be incorporated into new list of divisions to be published early this year.

To utilize the S.A.I.S. for cataloging books, periodicals, and matter covering a broader range of subjects, it was decided to provide, for discreet use, zero sections where needed in the various divisions.



NEW PUSHER PLANE IN FLIGHT

Anderson, Greenwood Model 14 in flight at Sam Houston Airport, Houston, Tex., showing distinctive cooling air intake ducts below wing center section leading edge. Exit area of ducts is located in immediate vicinity of the propeller. Low-pressure area ahead of prop is used to induce cooling airflow. Gross weight of the 14 is 1,400 lbs.; useful load, 550 lbs.; span, 34 ft.; wing area, 120 sq.ft.; top speed, over 120 m.p.h.; range on 23 gal. of fuel, 4 hrs. New plane is development of Anderson, Greenwood & Company, Houston, Tex., of which Ben M. Anderson, I.A.S. Technical Member, is President, Marvin Greenwood, I.A.S. Member, Vice-President; and Lomis Slaughter, Jr., I.A.S. Member, Secretary and Chief Engineer. Feature article on the 14 will appear in an early issue of the Review.

Priority was established for the coordination of the section breakdowns of the remaining divisions of the Standard Aeronautical Indexing System.

Among those present at the conference were Lt. Col. A. A. Arnhym, Chief, Air Documents Division, Chairman; Ned Thorne, Dayton Representative, S.A.I.S., Secretary; and Messrs., Leslie E. Neville, R. M. Woodham, Max Sokol, Keith Brown, and Harris Reeve of the S.A.I.S. headquarters staff of the New York office.

▸ **Announce C.A.D.O.**—In his opening remarks, Chairman Arnhym spoke of the establishment of the Central Air Documents Office of the Air Force and Navy at Wright Field, announcement of which was first made in Vol. 13, No. 22 (November 15) issue of the *Technical Data Digest.*

C.A.A. Reorganization Will Strengthen Nonskeds, Del Rentzel Says

At a meeting with his Non-Scheduled Flying Advisory Committee at the Civil Aeronautics Administration's Indianapolis Experimental Station, Delos W. Rentzel, C.A.A. Administrator and I.A.S. Honorary Member, said that reorganization of the C.A.A. will strengthen the promotion and development of nonscheduled civil aviation.

▸ **Broadens C.A.A. Interest**—He told the Committee that all C.A.A. divisions would be charged with responsibility of encouraging this phase of aeronautics, thereby broadening rather than restricting C.A.A.'s interest in this field.

Furthermore, Rentzel added, under new reorganization plan, he would continue to meet personally with the Non-Scheduled Flying Advisory Committee.

Principal action taken by the Committee at the Indianapolis meeting was in connection with forthcoming new regulation on flight tests. After extensive study, C.A.A. and Committee concluded that existing methods of pilot training have not only resulted in a continuingly bad stall-spin accident frequency but have also, in effect, discouraged manufacturers from building stall and spin resistant airplanes.

▸ **New Regulation Drafted**—To correct this situation a new regulation has been tentatively drafted in which emphasis in flight training will be shifted to a more thorough and intensive instruction in stalls.

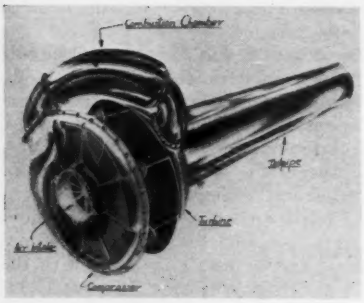
Accident record convinced Committee that it is imperative that our future flight-training curriculum include training that will reveal to the student that, in many aircraft, ailerons not only do not work at times but work in reverse. Committee felt that ability of prospective pilot to demonstrate this in a flight test was the key to the stall-spin problem.

The maneuver recommended for this purpose was that the applicants for pilot certificates demonstrate recognition of, and recovery from, a lateral stall induced by a fairly abrupt movement of the stick toward the high rear corner while in a moderately tight, slightly crossed-control power-on turn, provided that the airplane used for the test was capable of being caused to start out the bottom of a turn in this manner.

▸ **Accomplish Two Things**—The Committee felt this type of training would accomplish two things: (1) it would substantially improve the safety record, and (2) with spins no longer required, manufacturers would no longer meet strong sales resistance as a result of building spin-proof or spin-resistant planes.

New Design Details of Cal-Aero XLC-1 and Turbojet

Additiona nformation of Cal-Aero Technical Institute's sleek XLC-1 and its compact urbojet power plant has been furnish d by Tom U. Engelman, Director of Public Relations, Grand



Unique Turbojet to Power XLC-1: *Sketch showing basic power plant of Cal-Aero XLC-1 jet plane without accessories, fittings, or intake ducting. Basically a type "B" supercharger, only major components to be fabricated are the tailpipe, combustion chamber, and ducting. Expected to deliver 240 lbs. thrust at 22,000 rpm., engine will weigh approximately 170 lbs. Specific fuel consumption is calculated at 2.03 gal. per lb. of thrust per hour. Combustion chamber is twisted to permit smoother airflow.*

Central Airport Company, and I.A.S. Member.

▶ **Class Project**—Originally conceived as a class project for the Cal-Aero engineering classes, the single-seater plane is of all-metal construction, having a double taper wing in conjunction with a "butterfly" tail configuration.

Bicycle-type landing gear is employed, with two outrigger wheels installed on the wing for balance. The two main wheels are located along the centerline of the fuselage.

Having a wing span of only 20 ft. 10 in., overall length of 17 ft. 1 in., and overall height of 5 ft. 11 in., the Cal-Aero design is smaller than most conventional personal aircraft types. Gross weight is 1,278 lbs.

Air intakes for the engine are located alongside the fuselage just below the wing leading edge, while the exhaust is at the bottom of the fuselage forward of the tail assembly.

▶ **Performance**—Powered by a turbojet expected to deliver 240-lb. thrust, performance figures of the XLC-1 are based on this estimated output. Top speed will be 250 m.p.h. Fuel consumption at cruising speed is estimated at 75 gal. per hour, and range is 325 miles. Rate of climb will be 1,380 ft. per min.; service ceiling, 35,000 ft.

All parts have been kept simple in design in order to ensure ease of fabrication. One of the uses visualized for the jet plane is that of a drone for use of the Air Force, in addition to serving as a prototype for a personal plane version.

▶ **Low-Cost Engine**—Most interesting single aspect of the XLC-1 is the power plant. Resulting from more than 4 years of development work at Cal-Aero, the latest in a series of jet engines, developed from surplus materials, this unit promises to possess endurance qualities far in excess of those heretofore achieved.

The turbine and compressor units are basically a type "B" supercharger, Engelman said. The combustion chamber is of unique shape—actually twisted—to permit a smoother flow of air from the combustion chamber to the turbine.

To weigh approximately 170 lbs., most of the parts of the engine and the accessories will be standard units. Tailpipe, combustion chamber, and ducting are the only major components that must be fabricated.

Cost of the engine units on a production basis would be extremely low, it is estimated, in comparison with reciprocating types of substantially less horsepower.

Work on the plane is now in the mock-up stage with completion scheduled for next fall. Tests on engine units, now being fabricated, are set for this spring, all work being completed in Cal-Aero shops.

Northrop Sees Guided Missiles As Backbone of Future Defense

SPEAKING AT THE Library of Congress in Washington, John K. Northrop, pioneer aircraft designer, and President, Northrop Aircraft, Inc., declared that pilotless guided missiles, traveling at speeds of 1,200–1,500 m.p.h., possibly supplemented by a limited number of giant atomic-powered airplanes, will form the backbone of the U.S. Air Force's offense and defense by 1960.

▶ **Atom- Planes by 1960**—Vigorous development of atomic power plants, Northrop said in his talk, "Aviation History—1903 to 1960," would make it possible to have large airplanes driven by nuclear energy in service well before 1960. Because of their enormous expense, they will be comparatively few in number.

Of guided missiles, two predominant types will hold the stage at that time, Northrop said. First of these will be a long-range winged missile propelled by suitable power plants now in existence and capable of carrying large loads of TNT or any other destructive war head.

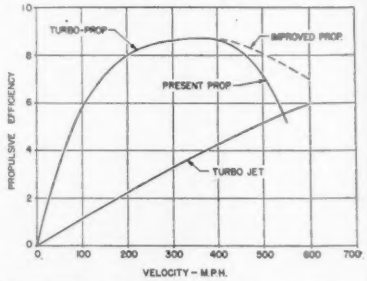
"The know-how for this missile operating at speeds of approximately 600 m.p.h. is presently available and is capable of extension to over 1,000 m.p.h. before 1960. . . . . It will have sufficient range for launching from continental United States against any desired target in the northern hemisphere and will be navigated by entirely automatic means," the speaker said.

Second type of missile will be ground-to-air interceptor, which will almost completely replace manned fighter aircraft, according to Northrop. It will be much smaller than present fighters, will be rocket-powered and equipped with automatic devices for guidance to its objective, and will constitute the sole effective defense against mass long-range enemy missile attack.

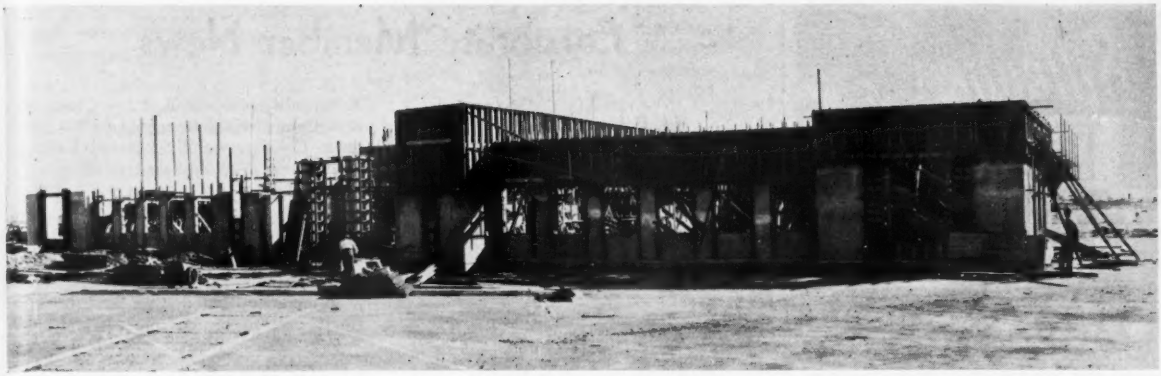
▶ **Turboprop Advantages**—Speaking of the relative efficiencies of the turbojet and turboprop engines, Northrop said that at "speeds between 400 and 500 m.p.h. the range of a turboprop-driven airplane may be nearly double that of one driven at the same speed by turbojets," although the efficiency of the engine itself is about the same in either case.

This is due to well-recognized mechanical law, Northrop explained, which dictates that for a given expenditure of energy a greater propulsive thrust can be obtained through moving a large mass of air at comparatively low velocity than a small mass of air at high velocity.

▶ **All-Wing Transports**—For civilian and military use, long-range transports of the all-wing type, similar to the Northrop Flying Wing, will be built with gross weights of from 100,-



Comparative Efficiency: *A comparison of the overall propulsive efficiency of a turbojet and turboprop at various speeds was given by Jack Northrop in his talk "Aviation History—1903 to 1960" at Library of Congress. Difference of height in the curves is the measure of the range of a given airplane if flown at same speed and with same amount of fuel in both cases.*



SAN DIEGO BUILDING TAKING SHAPE

Scene on Harbor Drive, San Diego, last November 5 when construction work on new San Diego Section headquarters had reached this point. By time this photo appears, exterior of the building will be practically completed. Occupancy is scheduled for some time in March.

000–200,000 lbs. and will be capable of cruising at speeds of about 500 m.p.h., driven by the new gas-turbine-propeller power plants, the speaker asserted.

These aircraft will have a direct operating cost of less than 5 cents per ton-mile of pay load.

Complete text of Mr. Northrop's speech is being published by The Library of Congress, Washington, D.C.

I.A.S. Newslines

▶ **Preston R. Bassett,** Past-President of I.A.S., and President of Sperry Gyroscope Company, was elected to the Corporation of Polytechnic Institute of Brooklyn. Mr. Bassett did postgraduate work at Brooklyn Polytech after he joined the Sperry Corporation in 1914 as a research engineer.

▶ Passport in Order . . . On eve of **Rex B. Beisel's** departure to new office in Dallas, to which he transferred as General Manager, Chance Vought Aircraft Division, Texas Governor Jester wired: ". . . Your Texas passports are all in order and safe conduct through Oklahoma is guaranteed. . ." Mr. Beisel, a Fellow, had been a resident of Stratford, Conn., for 9 years.

▶ Succeeds Bush to N.A.C.A. . . . **Dr. Karl T. Compton,** I.A.S. Fellow has been sworn in as a Member of the National Advisory Committee for Aeronautics, replacing Dr. Vannevar Bush by reason of his succession to Dr. Bush as head of the Research and Development Board.

▶ Heads New Board . . . Secretary of Defense James Forrestal announced plans for development of a National control system of navigation and air traffic control, with **Ralph S. Damon,** I.A.S. Fellow, and President, American Airlines, as Chairman of the Air Navigation Development Board. In developing an air navigation system, board will link the control web with national defense system as far as possible.

▶ "Meritorious Conduct" . . . **Dr. Kenneth S. M. Davidson,** Director of Experimental Towing Tank, Stevens Institute of Technology, Hoboken, N.J., and I.A.S. Associate Fellow, was awarded a certificate of merit, signed by President Truman, for "outstanding fidelity and meritorious conduct" during World War II.

▶ Still Need Business . . . Aircraft makers still have idle capacity available for types being exported, and 21 of 22 principal manufacturers are maintaining or increasing export sales activity, according to **Major Gen. Oliver P. Echols,** President, Aircraft Industries Association, and I.A.S. Associate Fellow. Of all civil types made in 1947, 25 per cent were sold abroad, he said. Total exports of all aircraft and aircraft products was $175,000,000 in that year, he added.

▶ Engineering firm of **Frederic Flader,** a Fellow and President-General Manager, Frederic Flader, Inc., North Tonawanda, N.Y., has made arrangement with Clark Bros. Company, Olean, N.Y., by which Clark will produce and distribute gas turbines and axial compressors designed by Flader for general industrial use. Flader will undertake research, engineering, and design.

▶ F-80 with Afterburner . . . **Hall Hibbard,** I.A.S. Fellow and Vice-President, Engineering, Lockheed Aircraft, said an F-80 using an afterburner obtained 30 to 80 per cent more thrust than the plane's normal 5,000 lbs. Speaking of jet transport future, Hibbard stated it will be a certainty in 6 to 8 years. A transport capable of carrying 50 passengers 3,500 miles nonstop at a fare 25 per cent less than present rates would have to have a turbojet with specific fuel consumption of 0.80 lbs. per lb. thrust per hr. Such an engine already is under development by Air Force, he added.

▶ Studies Alaska Air Ops . . . Air Force sent **Charles A. Lindbergh,** I.A.S. Fellow, as special consultant to study technical problems of Alaska air operations. Colonel Lindbergh also visited air bases in the Pacific.

▶ 4,000 Air Markers . . . More than 4,000 air markers have been installed during 1947–1948, reports **Delos W. Rentzel,** C.A.A. Administrator and I.A.S. Honorary Member. Goal is 100,000 serviceable markers, said the Administrator, which will not be reached "if we must follow our present method of installing" them. Marker lasts for maximum of 3 years without repainting.

▶ Transferred . . . **Edwyn G. Rydlun** has transferred to the Air Force from War Assets, where he was Supply Officer. New position: Industrial Planning Specialist, Hq. U.S. Air Force, Deputy Chief of Staff—Materiel. Mr. Rydlun is an Associate Fellow.

▶ With R.D.B. . . . **Harry A. Sutton,** Engineering Director of Ryan Aeronautical Company, has been appointed Chairman of a panel on the Committee for Guided Missiles of the Research & Development Board. An I.A.S. Fellow, Sutton also has been Selected as a Consultant to the Committee. Jobs are part-time and will not interfere with his position at Ryan.

▶ Joins N.A.C.A. . . . Associate Fellow **Charles H. Zimmerman,** who was with Chance Vought Aircraft Division, United Aircraft Corporation, has been appointed Aeronautical Research Scientist with National Advisory Committee for Aeronautics.

Silicone News

DC SILICONES

New Solution to an Old Problem

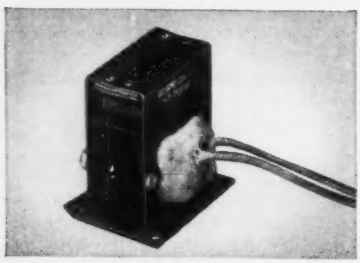


PHOTO COURTESY DETROIT COIL COMPANY

Solenoid insulated with inorganic components and DC 996 Silicone Varnish operates continuously on a 32 volt DC system but is the same size as conventionally insulated solenoids operating on 220 volt AC current.

Increasing the power rating of electrical equipment without increasing equipment size is an old problem to the electrical engineer. And for years it has remained a partially unsolved problem because of the heat limitations of Class A and Class B insulation. Now, however, a complete solution is available in DC Silicone Insulation, the insulation that makes possible continuous operation of electrical equipment at temperatures as high as 500°F.

Engineers of the Detroit Coil Company of Detroit know from experience how DC Silicone Insulation solves insulating problems. They were asked to build solenoids able to operate continuously on a 32 volt DC system but using the same size frame as required for a solenoid operating on a 220 volt AC current. Ordinarily, a larger solenoid would be used, but in this particular application space was a limiting factor and the cost of a design change was prohibitive.

Detroit Coil engineers solved the problem by building solenoid coils insulated with inorganic components and DC 996 Silicone Varnish. Although the conventional frame structure for alternating current was used, glass-silicone insulation made possible the 32 volt DC rating by permitting much higher operating temperatures.

Dow Corning Silicone Insulation is also used to build motors, generators, and dry type transformers with the same rating but about one-half the size of conventionally insulated equipment. More information is given in Booklet No. G4-S.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
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Dow Corning
FIRST IN SILICONES

Corporate Member News

• DC-6, Convair-Liner Decrease Unit Cost . . . **American Airlines, Inc.,** finds that DC-6 and Convair-Liner equipment have decreased unit cost, reducing the break-even passenger load factor for September to 55.4 per cent. Family plan continues to account for about 10 per cent of American's total passenger business . . . Some DC-3 schedules will be continued until May because of airport limitations which, upon correction, will permit utilization of DC-6's and Convair-Liners to be operated on all passenger flights. DC-4's will be retained for all-cargo schedules.

• Backlog Increased by Navy Contract . . . **Beech Aircraft Corporation's** production backlog has been considerably increased by award of Navy contract for modification and overhaul of 457 military two-engined Beechcrafts. Modification contract calls for about 1,250,000 man-hours of direct labor, with production schedules calling for deliveries of from 27 to 64 completely overhauled planes a month starting last November through June . . . Nonaircraft production at Beech includes half-million dollar contract for dishwasher units for the Kitchen Kraft Corporation, a contract calling for aluminum trays for Seeger Refrigerator Corporation, and one for component parts for cotton pickers and hay balers for International Harvester Company.

• Closing the Gap . . . **Boeing Airplane Company** had net loss of $298,820 for 9 months ended September 30—semi-annual report showed net loss of $1,074,510. Sales and other income for 9-month period totaled $71,703,776. More than half of Boeing's Air Force procurement funds will be diverted to subcontractors and other suppliers, with 325 B-50D, B-54, C-97A, and B-47 aircraft involved . . . Certification of the Stratocruiser for gross of 142,500 lbs. was announced in November, coincident with C.A.A. approval of operation manual for new 340-m.p.h. double-deck air liner. Design useful load of more than 30 tons is higher by a considerable margin than any commercial transport ever licensed in this country, Boeing says . . . Boeing—Wichita has been facing a shortage of engineers and technicians as it prepares for B-47 program. About 400 production engineers are needed as we go to press. . . A B-29 reached an altitude of 48,462 ft. on a routine flight, setting an unofficial B-29 altitude record.

• Sales Report . . . **Cessna Aircraft Company** reported a sales volume of $14,250,000 for fiscal year ended September 20, increase of 40 per cent over 1947 sales. Sales were evenly divided between two- and four-place planes, 800 each, more than any other personal plane manufacturer. . . Air Force is reported to be negotiating a contract for twelve Cessna Model 195 liaison planes, described by leading Alaskan bush pilots as best light plane available for rescue work in rugged country, whether on wheels, floats, or skis. Cessna employs around 1,600 in its two plants at Wichita and Hutchison, Kan.

• Assault Transport Test . . . **Chase Aircraft Company's** two-engined assault transport, C-122, was flight-tested early in November.

• Convair XP5Y-1 to Fly Soon . . . First experimental model of the XP5Y-1 flying boat built by **Consolidated Vultee Aircraft Corporation** is expected to fly early this year. Plane is powered by Allison turboprop engines developed under Navy contract, said to be capable of developing "more thrust output horsepower per pound airplane weight than some modern fighter aircraft." Much of aerodynamic test work was done with radio-controlled flying model . . . Company has moved its, Washington office from 1625 K St., N.W. to 1612 K St., N.W.

• Consolidated net profit for 3 months ended September 30 of $562,864 after taxes was announced by Guy W. Vaughan, President, **Curtiss-Wright Corporation.** Net sales for the period amounted to $24,121,701 for C-W and its subsidiaries. Unfilled orders on hand were $134,200,000 at September 30, compared with $146,500,000 at June 30, 1948.

• Reporting a net income of $1,950,795 for first 9 months of fiscal 1948, **Douglas Aircraft Company** earnings in third quarter topped previous quarters because of accelerated delivery schedules. Company's backlog at August 31 stood at $202,201,000, increase of $52,509,000 from beginning of third quarter, total not including commitments for $70,000,000 of military contracts not then signed. Employment had risen from 13,500 at midyear to about 15,000. . . C-124 will fly at year-end, Douglas officials estimate. Powered by four Pratt & Whitney R-4360-49 engines of 3,500 hp. for thrust output with water injection, it is similar to C-74 in all but fuselage, which was redesigned and enlarged. New plane will carry 50,000-lb. pay load at gross of 175,000 lbs. Effective radius at maximum pay load is 1,200 miles. Air Force has ordered 28.

• Familiar Story . . . **Eastern Air Lines, Inc.,** reported a net profit after taxes of $762,578 in first 9 months of 1948 as compared with a net of $409,809 in same 1947 period.

• Five Photos per Second . . . **Fairchild Camera & Instrument Corporation** is developing a new camera for Tactical Air Force to record bomb damage by fast, low-flying aircraft. New "strike attack" camera will use 70-mm. film at rate of 5 per sec., using shutter speeds up to 1/2,500 sec.

• Fairchild Invests in Atomic Research Program . . . **The Fairchild Engine and Airplane Corporation** has become one of the industrial sponsors of the University of Chicago's basic atomic and metal research program "as a means of keeping pace with scientific developments that may have a tremendous impact on the company's products and processes," J. Carlton Ward, Chairman of the Board, said. Under industrial membership plan Fairchild will send research specialists to

the university for quarterly conferences to discuss current progress and new techniques in basic science.

• Air Force announced that a $6,500,000 contract has been signed with **General Electric Company** for manufacture of fire-control systems. Production is to begin in 6–7 months in the former Remington Rand plant in Johnson City, N.Y., that company has leased from War Assets . . . G-E is building an a.c. network analyzer for installation at the Indian Institute of Science, Bangalore. When completed this year, instrument will have application in the solution of a variety of problems, in addition to reproducing in miniature the electric circuits of vast power system networks and solving mathematical problems associated with them. These include the study of airflow over an airfoil, flow of liquid through a network of pipes, stress analysis, and vibration of machinery.

• Meeting Power Shortage . . . **The B. F. Goodrich Company,** Akron, faced with severest power shortage country has known which is expected to continue throughout winter, has transferred certain processing production from day to night shifts to prevent curtailing of Akron operations. . . A revised catalog section on adhesives has been published by Goodrich and is available on request.

• Back in Military Production . . . After 3 years in the civilian field following last war, **Goodyear Aircraft Corporation** is once again back in military goods business. Production contracts currently include aircraft parts, fuel tanks, and radar equipment.

• Electrical Computer for Engineers . . . **Goodyear Tire & Rubber Company** has an electrical computer that, they say, solves complex mathematical problems in matter of seconds. What's more, it is capable of solving 90 per cent of all computations used by aircraft research engineers. Unit is 2 ft. square, is 6 ft. tall, and weighs about 800 lbs. It contains 100 radio tubes used in some 20 amplifiers that transpose electrical signals into mathematical answers. Operation is so simple, Goodyear says, high-school graduate can learn to use it in a month.

• Making Room . . . Aluminum truck body production is being moved by **Grumman Aircraft Engineering Corporation** from its Bethpage, L.I., plant to a factory purchased in Athens, N.Y. More room was needed for expanding aircraft production.

• "Blood Test Method" for Inspection of Parts . . . Said to be 50 times more effective in ferreting out defects and much cheaper than the traditional piece-by-piece checking method, a "blood test method" was outlined at the A.S.M.E. meeting by Dorian Shainin, Chief Inspector, **Hamilton Standard Propellers, Division,** United Aircraft Corporation. Lot size of materials inspected by new method has to be something over 50 pieces. Regardless of lot size, however, required sample size remains at around 50 pieces in order to maintain the risk at same low level.

• Most Powerful Crash Truck . . . **Walter Kidde & Company,** Belleville, N.J., demonstrated their Model "D" airport crash truck, described as most powerful in world. Truck is capable of discharging up to 2,400 gal. per min. of foam through two reel and two turret nozzles for 2.1 min. Equipment consists of two extinguishing systems—mechanical foam and carbon dioxide.

• New and Cheaper Synchrotel Unit . . . **Kollsman Instrument Division,** Square D Company, has announced a new and cheaper synchrotel unit weighing one-third as much as former unit yet having an electrical output 500 per cent greater.

• Revolutionary . . . A revolutionary new VHF visual direction-finder for airplanes, known as the Omnimatic, is offered by **Lear, Inc.,** as a contribution to safe flying for all pilots. Unit weighs 24 lbs. and can be installed for about $700, receives VOR signal and converts it in a twinkling to a compass bearing visible on instrument panel.

• McDonnell Ramjet 'Copter Tested . . . In its initial public flight test, **McDonnell Aircraft Corporation's** small ram-jet helicopter has proved successful. Two tip ram-jets, a small rudder, and open steel structure supporting pilot, controls, and fuel tank comprise the machine.

• New Metal-Forming Process . . . **North American Aviation, Inc.,** is using a new metal-forming process consisting of "pre-stretching" an aluminum sheet before it is pulled over a die. New method provides formed parts with closer limits and more uniform strength and reduces "spring-back" to minimum. Specially built stretching machine, with jaws capable of exerting 50-ton pull, grips either end of metal sheet and stretches it around die.

• Flying Wing Cruises 3,400 Miles . . . Taking off at less than design gross weight of 213,000 lbs. and with fuel tanks only partly full, the B-49 Flying Wing designed and built by **Northrop Aircraft, Inc.,** has flown 3,458 miles in 9½ hours in test flight at Muroc Air Base.

• Northwest to Honolulu . . . **Northwest Airlines, Inc.,** started service of three flights weekly each way early last month to Honolulu, using DC-4 equipment to begin with, pending delivery of Boeing Stratocruisers. Flights originate and terminate at Seattle-Tacoma, about 1 hour's flight time from Portland.

• First of **Pan American World Airways'** Boeing Stratocruisers was delivered December 15. Pan Am has 20 on order, to be placed in Pacific service, flying between San Francisco, Honolulu, and Los Angeles . . . West Coast dock strike has developed some nice business in Pan Am's Hawaii and Alaska cargo schedules. According to company, total of 831,000 lbs. of cargo was flown to Hawaii and Alaska last October, whereas in August, last pre-strike month, only 400,000 lbs. were carried. In the 60-day period, September 9 to November 9, Pan Am estimates it has flown 1,150,000 lbs. from Seattle to Alaska. Twenty-six extra sections were operated during the 2 months.

• Pratt & Whitney Supplies 77 Per Cent of all U.S. Air-line Engines . . . With, 2140 Double and Twin Wasps in use, **Pratt & Whitney Aircraft Division,** United Aircraft Corporation, reports that slightly more than 77 per cent of all power plants installed in U.S. commercial airliners are Pratt & Whitney engines. With 955 planes in scheduled operation, domestic lines have 2,814 engine installations, 2,140 of which are Pratt & Whitney. Nonskeds are not included in the count.

• **Republic Aviation Corporation** had a net after taxes of $2,274,870 for first 9 months of 1948 on sales of $39,371,559. Net earnings include a carry-forward Federal income tax credit from 1947 operations of about $397,000. Republic has an experimental contract for a new fighter, the XF-91.

• On 6-Day Week . . . **Rohr Aircraft Company,** Chula Vista, Calif., has taken up the 6-day, 48-hr. week to meet expanding production demands. Company specializes in power-plant assemblies for Boeing, Lockheed, and Convair. Payroll totals, 2,600.

• Deliveries of **Ryan Aeronautical Company's** four-place Navion personal-business planes reached a new monthly high in October of 74, exceeding previous record of 71 in June, normally the peak of the selling season. Total Ryan Navion sales to October 31 were 484, of which 41 were for export. Ryan has been working on a $2,500,000 Air Force contract for 158 L-17B Navion liaison planes and spares equal to about 60 more complete planes. Company is now swinging into 1949 sales year on the commercial Navion.

• Refueling from Hydrant . . . **Standard Oil Company of N.J.** demonstrated an aircraft refueling system of hydrants located along apron of an airfield at McGuire Air Base, Ft. Dix, N.J. Designed to reduce fire hazard by eliminating large quantities of gas carried by trucks, new system saves time lost in refueling tank trucks and eliminates most of movement of large trucks in congested area while servicing planes. Esso says system results in reduction in installation, maintenance, and operating costs. Moissant International Airport, New Orleans, and Gander, Newfoundland, already have hydrant system in operation.

• Strategic Spot . . . **United Air Lines, Inc.,** has opened a ticket office three doors from the Brown Derby on Vine St., Hollywood. Office features air conditioning, tropical plants, murals, fluorescent lighting, and all-glass front . . . UAL chalked up 500,000,000th plane-mile November 15 since April 6, 1926, when service was inaugurated by Varney Air Lines, United's first predecessor.

• Buys West Coast Plant . . . **Westinghouse Electric Corporation** has bought the 57-acre Sunnyvale, Calif., works, leased 21 months ago from the Joshua Hendy Iron Works. Move is indicative of company's confidence in business and industrial future of West. Westinghouse already has invested several million dollars in machinery and equipment, and facilities are being expanded continually. Production of distribution and power transformers, a.c. motors, steam turbines, valves, gears, etc., is under way.

544656

Necrology

Brig. General William E. Gillmore

Brigadier General William E. Gillmore, U.S.A. (Ret.), I.A.S. Member, died November 7 at Walter Reed Hospital in Washington, D.C., at the age of 71.

▶ **Aviation Consultant**—At the outset of World War II, General Gillmore attempted to return to active duty but was advised by the Secretary of War that, with his aviation knowledge (he served as Assistant Chief of the Army Air Corps from 1926–1930), he could be more helpful in a civilian capacity, expediting materials for the Air Forces.

He then went to work as consultant to Briggs Manufacturing Company, which was making key parts for combat planes.

At the war's end he received the commendation of the Secretary of War and of Gen. H. H. Arnold, then Chief of the Air Forces.

▶ **Attended West Point**—General Gillmore, born in Ohio, was at West Point Military Academy when the Spanish-American War began. He served as a Lieutenant during that conflict.

He became interested in aviation in World War I, and later as a lieutenant colonel he was procurement officer for the service.

In 1921 he was graduated from the Army Flying School as a pilot in the bombardment section of the Signal Corps.

▶ **At Wright Field**—From 1926 to 1932 he was commandant at Wright Field, where he was in charge of construction of the field and at the same time chief of procurement for the Air Corps.

When he was placed in charge of Wright Field, it was in process of development as a research laboratory and proving ground. Under his direction many advances in Army aviation were made, including development of a cooling fluid for engines.

Meet Your Section Chairman

Milton B. Ames, Jr.

Washington Section

Milton Ames, who became a Student Member of the Institute in 1934 while an aeronautical engineering student at Georgia Tech, has been interested in aeronautics ever since he can remember being interested in any profession.

Living in the vicinity of the Hampton Roads Naval Air Station and Langley Field until college age, the advances in aeronautical design, especially those leading to even higher speeds and greater ranges of airplanes, always fascinated him. Along with this was an inherent and persistent desire to participate and contribute to these advances.

▶ **Organized Company**—Turning desire into action, Ames became active in model airplane building in 1928 when he was 15, organizing and operating the Ames-Harrell Model Airplane Company, which manufactured and sold model airplane kits in practically every state until 1931. Some of the models were designed in a small wind tunnel, which he constructed in 1930.

Previous to this, the loss of the Schneider Cup Trophy by American to Italian flyers in 1926 had made a deep impression on him, furthering his ambition to make aeronautics his profession.

Born in Norfolk, Va., he attended the Matthew Fontain Maury High School and, later, the Norfolk Division, College of William and Mary—Virginia Polytechnic Institute, where he studied mechanical engineering from 1931–1933.

Completing his third-year classes in mechanical engineering at Georgia Tech, he was then selected on scholarship to study aeronautical engineering there at the Guggenheim School of Aeronautics. He received his B.Sc. in Aeronautical Engineering in June, 1936.

Ames learned to fly in 1935, soloing after 7 days' instruction in an OX-powered Bird biplane. He received his pilot's license at Langley Field on August 15 of that year and, since then, has flown, in addition to the Bird, a variety of personal aircraft types, including the Stinson Reliant, Fleet biplane, Monocoupe, Rearwin Sportster and Fairchild "24," of the older models, and Piper, Aeronca, and Taylorcraft, among later model aircraft.

▶ **Appointed N.A.C.A. Engineer**—Following his graduation from the Guggenheim School of Aeronautics, Ames was appointed Aeronautical Engineer at Langley Memorial Aeronautical Laboratory of the National Advisory Committee for Aeronautics where he was assigned to the free-spinning wind tunnel, working on arrangement and design of component parts of the N.A.C.A. general research model airplane for the free-spinning wind tunnel.

He remained at Langley until 1941, specializing in research on high-lift devices, control surfaces, and general stability and control work. While working at Langley, Ames was an instructor in aerodynamics, engineering principles of aircraft design, and flight ground school at the Norfolk Division, Virginia Polytechnic Institute evening sessions during 1940–1941.

Having been promoted to the position of Assistant to the Chief of Aerodynamics at Langley, Ames was appointed Engineering Assistant to the late Dr. George W. Lewis, then Director of Aeronautical Research, N.A.C.A., in November, 1941. During the war he also served as Technical Assistant to C. H. Helms, N.A.C.A. Chief of Military Research, in Washington. He is now a member of Dr. Hugh L. Dryden's staff, carrying out N.A.C.A. headquarters duties in aerodynamics, assisting in research planning, interlaboratory coordination, and liaison activities.

▶ **N.A.C.A. Publications**—In his 12 years with N.A.C.A., Mr. Ames has authored or collaborated in some 14 N.A.C.A. reports and memorandums concerned with wind-tunnel research on wings, flaps, and tail surfaces.

These reports were of particular value to the industry.

In 1944 he married Martha Nuland, of Lodi, Calif. They have one daughter, Carol Diane.

Mr. Ames continues his interest in model aircraft building as a hobby, along with speed boating, and enjoys swimming, bowling, and music (he plays the violin) as a means of relaxation.

Elton H. Rowley

Wichita Section

Now Chief of Flight Test, Boeing, Wichita, Elton H. Rowley first got into aeronautics building model airplanes back in 1925—when he was about 14—and 5 years later had designed and built a glider. He learned to fly and then went into the Army, graduating from the U.S. Army Technical School, Ft. Monmouth, N.J. in 1933.

▶ **3,500 Hours**—At the age of 37, Rowley has logged 3,500 hours as a pilot, flying all common commercial types, in addition to the B-29, B-50, XL-15, and BT-13 aircraft.

Two of the most interesting events of Mr. Rowley's aeronautical career were his first flight in a B-29 and his first flight above 35,000 ft. In his position at Boeing, he is responsible for all flight operations for the Wichita Division, both engineering and production.

Following his graduation from Army Tech at Ft. Monmouth, Rowley was assigned to the 15th Observation Squadron, Scott Field. He also had some lighter-than-air experience with the 9th Service Squadron based at Scott Field.

▶ **Assisted in 'Explorer I' Flight**—In 1933–1934 he assisted in gathering meteorological data in the Middle West prior to the high-altitude flight of the balloon, "Explorer I."

During the last war Rowley was responsible for considerable high-altitude development on the B-29, being in charge of all B-29 research flying. He has been with Boeing 5 years.

▶ **Interested in Gliders**—With soaring and gliding a hobby, Rowley has spent considerable time and personal capital designing and building an attachable power unit for gliders. He has completed the first unit, including a test platform glider—designed and built in the last 5 years.

Another development on which he is working is high-lift devices for light planes. He has flown many such devices for Boeing, particularly the XL-15, currently being built at the Wichita plant.

▶ **Folding Prop**—Another of Rowley's developments is a folding propeller for power gliders and prop-jet aircraft on which he holds a patent.

A paper, "Design for Power Soaring," written by Rowley, appeared in *Soaring* magazine and the *S.A.E. Journal* and was reprinted in the British aeronautical weekly, *Flight*, under the title, "Aspects of Power Gliding."

To relax, Mr. Rowley takes his family for a spin in a plane or, if the weather is soupy, works in his home shop building small engines.

I.A.S. Sections

Baltimore Section

Don K. Covington, *Secretary*

Approximately 150 members attended a dinner meeting at the University of Maryland Dining Hall, College Park, Md., October 21, Chairman O. J. Schaefer presiding.

At the end of the dinner, Chairman Schaefer introduced Prof. A. W. Sherwood, Professor of Aeronautics, of the University, who expressed the University's welcome and then continued with his prepared address outlining the development of the new University of Maryland Wind Tunnel.

▶ **Martin Gift**—The Wind-Tunnel project was made possible by the $2^1/_2$ million dollar endowment present $3^1/_2$ years ago by Glenn L. Martin, Past-President and Honorary Fellow of the Institute.

This modern subsonic wind tunnel was expected to be in operation late last November.

Buffalo Section

A. H. Flax, *Secretary*

New 1949 officers were elected at the September 29 meeting as follows: Chairman, George D. Ray; Vice-Chairman, Robert W. Kluge; Secretary, Harrison Dunlavy; Treasurer, Walter O. Breuhaus. Members of the Advisory Committee are as follows: Robert J. Woods and Dr. Clifford C. Furnas.

▶ **Prevent Air Sickness?**—At the October 20 meeting, Dr. G. R. Wendt, Chairman, Psychology Department, University of Rochester, in a talk entitled "Can We Prevent Air Sickness," discussed the physical, physiological, and psychological factors involved in air sickness.

He attributed most of the difficulties to the effect of vertical acceleration on the inner ear. This suggested a simple cure involving only inclining head, which is now being investigated further.

Dr. Wendt described the "nauseator," a device used to subject human beings to various frequencies and amplitudes of motion. One interesting result obtained from his tests is that the curve of human susceptibility to sickness caused by oscillatory motion versus frequency results in a curve similar to the resonance curve of a simple mechanical system. Critical frequency for air sickness is 20 cycles per min., he said.

Dr. Wendt also discussed the use of drugs for prevention of air sickness, stating that hyoscine was effective.

▶ **Reducing Fatalities**—Second speaker, E. R. Dye, Manager, Development Division, Cornell Aeronautical Laboratory, dealt with problem of reducing fatal injuries in air accidents. He pointed out the importance of head injuries, describing means to protect the head. These include shoulder straps; use of locally yielding materials in vicinity of head, particularly on the instrument panel; and use of energy-absorbing devices in aircraft structure.

Cleveland-Akron Section

Dr. S. Doree Black, *Secretary*

"Modern Scientific Progress in Astronomy" was the title of a talk by Dr. Jason J. Nassau, Professor of Astronomy at Case Institute of Technology and Director of Warner & Swasey Observatory, at the October 26 meeting. Dr. Nassau's talk included current applications of astronomy to aviation.

Columbus Section

F. L. Jesse, *Secretary*

First meeting of the new Columbus Section was opened on November 16 by Chairman C. J. Peirce, Jr., Ohio State University, who introduced the temporary officers as follows: Vice-Chairman Dr. David T. Williams, Battelle Memorial Institute; Secretary, F. L. Jesse, Curtiss-Wright Corporation; Treasurer, A. A. Adams, Curtiss-Wright Corporation.

Mr. Peirce then commended Messrs. M. T. Hockman, Francis Janik, Walter Laster, Robert Lemmon, and Robert Mendelsohn, who, together with the officers, had formed a Steering Committee under chairmanship of Mr. Jesse and had done an excellent job in organizing and establishing the Section.

Meeting was then turned over to Mr. Jesse who introduced Thomas J. Meskel, Manager, Member Services, I.A.S., who read a telegram from S.

Paul Johnston, I.A.S. Director, in which he pledged the cooperation of the New York office and extended congratulations to the newly formed Section.

▶ **General Craigie Speaks**—Chief speaker was Major Gen. L. C. Craigie, Commandant, Air Forces Institute of Technology, who spoke on "The Role of Research and Development in Insuring Effective Air Power."

General Craigie said that, because of the new vulnerability of the U.S. to air power, it is necessary not only to develop the most modern aircraft and communications but also to train personnel to make full and effective use of all defensive and offensive weapons.

Dayton Section

Robert Crawford, *Secretary*

At the business session held October 15, Section Chairman A. A. Arnhym presented the following members who were unanimously approved to office: Corresponding Secretary, Major W. A. Barden; Recording Secretary, Lt. Robert Crawford; Treasurer, A. B. Deyarmond; and Program Chairman, E. Kotcher.

▶ **'Morphology' of Propulsion**—Dr. Fritz Zwicky, Chief of Research, Aerojet Engineering Corporation, Azusa, Calif., spoke on "Morphology of Aerial Propulsion." He gave an outline of the various fundamental means of creating propulsion which could be suitably applied to present and projected types of turbojet, ramjet and pulse-jet engines.

Hagerstown Section

J. Anthony Pauli, *Secretary-Treasurer*

At the Section's dinner meeting held October 29 with 110 members and guests present, Col. John A. Wallace, Beaver College professor, addressed the meeting on "Future Airborne Requirements."

▶ **Army Wants More C-82 Type**—Wallace told his audience that the Army is interested in getting more of the C-82 type aircraft so that it can pick up a division of men and set them down anywhere, regardless of the size of the landing field or weather conditions.

Saying that the Army has asked for a troop carrier with 10-ton capacity, Wallace added that Fairchild Engine and Airplane Corporation aims to fill the request with the C-119-B.

He emphasized that the present problem in Germany is getting ships in and landed, and he declared that, if a plane can be produced which can drop its cargo without landing and then return to its base, operations would be greatly facilitated.

▶ **Pack Plane for Front**—Army also wants a small pack plane for use right up at the front, Wallace said.

Slides of scenes taken during his European trip accompanied his talk.

▶ **New Officers**—Taking over as Chairman at the meeting was Herman Wieben, succeeding Roy Lessard. New Vice-Chairman is Lyle Lutton, while the new Secretary-Treasurer is Jim Crook. Advisory Council members are Armand Thieblot, Roscoe Markey, Bob Kirby, and Roy Lessard. Hank Billings is the Representative to the Area Nominating Committee.

Philadelphia Section

J. Albert Roy, *Secretary*

Virgil Kauffman, President, Aero Service Corporation, Philadelphia, addressed the Section at the November 3 meeting on "Modern Aerial Mapping."

▶ **Precision Mapping**—Mr. Kauffman's talk dealt with modern precision aerial mapping for industry and Government. He discussed the making of precise photomosaics, as well as the production of topographic and planimetric maps from an aerial photographic base.

He also described his firm's use of the air-borne magnetometer, the important new geophysical exploration tool that is being used by oil and mining companies for the location and delineation of new resources.

Color movies taken during aerial mapping operations in Canada, Holland, and Africa also were shown.

San Diego Section

W. K. Immenschuh, *Secretary*

Title of the talk given at the October 21 meeting by Robert E. Day, Project Engineer at Solar Aircraft Company's San Diego plant, was "The Afterburner—More Power for Today's Turbojet Engines."

▶ **Auxiliary Device**—An afterburner is an auxiliary device to increase military thrust rating of turbojet engines for short periods of time, Day explained, adding that an afterburner is essentially a specially designed exhaust tailpipe into which fuel is injected and burned, resulting in an increase in exhaust gas jet velocity and thrust.

Mr. Day's talk covered afterburner control system and development problems, as well as the advantages obtained from its use with turbojet engines.

Wichita Section

H. E. Dickard, *Secretary*

Guest speaker at the November 4 meeting was Fred Weick of Texas A & M Personal Aircraft Research Center. Fifty-one members and guests attended the dinner with Elton H. Rowley, the new Chairman, presiding.

▶ **'How Much Lift'**—Mr. Weick's talk centered on the problem of increasing the speed range of personal aircraft. Up until recently, the Texas A & M Research Center had dealt principally with the low-speed phase of the problem, on the ability to get into and out of small fields. Mr. Weick stated that the natural point of departure in any such investigation, the study of high-lift devices, soon leads to the question, "How much high lift do we want?"

Many high-lift arrangements, he said, soon reach a point of diminishing returns, after which the particular aircraft involved ceases to benefit from them.

Student Branches

Academy of Aeronautics

A film, *Construction of a Lightplane*, was shown at the October 13 meeting, Chairman John Peter Keilp presiding. The film showed methods used in manufacturing a Piper Cub.

The meeting at the Hotel Astor on October 26 heard Capt. Charles Yeager and S. W. Smith, Project Engineer on the Bell X-1, who gave interesting talks concerning their experiences with the supersonic experimental plane. Charles Froesch, of Eastern Air Lines, presided at the meeting.

Aeronautical University

At the November 10 meeting members heard 2nd Lt. N. T. Guttenberger, Air Force Reserve, on the subject, "Design Features and Operation of Helicopters."

Lieutenant Guttenberger, who has a total of 200 hours' flying time in Sikorsky helicopters, based his talk on experiences as helicopter flight instruc-

tor at the Sikorsky Aircraft Plant at Bridgeport, Conn.

Catholic University

Following a business session at the November 3 meeting, members heard a talk by Mr. Matthews, of the Investigation Division, Civil Aeronautics Board, who gave a "Summary of Procedure in an Air Crash Investigation." Presiding was Chairman Marcian A. Herman.

University of Colorado

Two films and a talk on "Jet Propulsion" featured the November 2 meeting, Chairman Robert M. Wood presiding.

Frank P. Durham, Instructor, Aeronautical Engineering, at the University, drew comparisons between turbojets and reciprocating engines with regard to power available, thrust, and fuel consumption.

The films shown were from Bell Aircraft Corporation, *Modern Magic Carpet, No Helicopters*, and *Report on Jet Propulsion.*

Georgia Institute of Technology

Vice-Chairman Dyke Wilmerding presided at the November 2 meeting in the absence of Chairman Barrett.

Professor H. W. S. LaVier, Associate Research Professor, gave a talk on the Curtiss SB2C, outlining the history, design, and development of the aircraft.

Illinois Institute of Technology

At the November 16 meeting of the Branch, principal speaker was I.A.S. Director S. Paul Johnston, who briefly outlined the background of the Institute as acting in the capacity of a professional society for aeronautical engineers and scientists. The aeronautical engineer, Mr. Johnston said, is a little hard to define because of the overlapping of specialized fields.

The Institute, he went on to say, attempts to coordinate all these fields by holding joint meetings and publishing papers for the benefit of all interested. Growth of the organization since the end of the war has been exceptional, as shown through the strength of Sections and Student Branches.

University of Illinois in Chicago

The new Branch held an election for officers November 13 resulting as follows: Chairman, Raymond E. Kreuger; Vice-Chairman, Edwin A. Arvesen, Jr.; Secretary-Treasurer, Naomi Sidney Suloway. Present membership is 23.

Members voted to request membership in the Engineering Council of the University, and Lloyd W. Gross was elected I.A.S. Representative.

UNIVERSITY OF FLORIDA FIELD TRIP

The Student Branch of University of Florida, on a field trip to Air Force base at Eglin Field, November 9, 10, and 11 examined latest type aircraft including the B-50, B-45, F-86, B-36, and F-82, as well as several guided missiles. Trip included a tour of the Climatic Hangar, which was then testing aircraft and equipment at −65° F. Chairman of the Branch, W. W. Petynia is third from left, kneeling. Professor R. A. Thompson, Honorary Chairman, is far left, standing.

University of Illinois

The film, *PBM Wing Destruction Test*, was shown at the October 14 meeting.

W. A. Brooks, Vice-Chairman talked about I.A.S. benefits and semester projects. The latter include an aircraft model meet and redecoration of the main hall of the transportation Building with material pertaining to aviation.

University of Kansas

On October 2 members elected new officers as follows: Chairman, William H. Wetz; Vice-Chairman, Paul D. Wilson; Secretary-Treasurer, Paul H. Jackson, Jr.; Social Chairman, Charles W. Spieth.

Chief speaker at the October 20 meeting was Manley J. Hood, Aeronautical Research Scientist, Ames Aeronautical Laboratory, N.A.C.A., who showed a film of the Ames Aeronautical Laboratory and answered questions about working conditions and employment opportunities at the Laboratory.

Members of the faculty of the Department of Aeronautical Engineering at the University of Kansas unanimously agreed that Paul W. Hare was the winner of the Scholarship Award and Robert L. Aker had earned the Lecture Award.

Both men will receive free membership for a limited period in the Institute of the Aeronautical Sciences as Technical Members.

Mr. Aker's winning lecture was "Report on the Goodyear Cross-Wind Landing Gear." He lives in Kansas City, Mo., while Mr. Hare comes from Dodge City, Kan.

Massachusetts Institute of Technology

Dr. Jerome C. Hunsaker, I.A.S. Honorary Fellow and Head of the Department of Aeronautical Engineering at M.I.T., gave the first of a series of talks October 13 on the analysis of the course in Aeronautical Engineering. In summary, he outlined job possibilities and the availability of graduate work leading towards advanced degrees.

At the meeting held October 27, Prof. S. Ober, Department of Aeronautical Engineering, M.I.T., classified the various jobs available in the field of aerodynamics, giving the general requirements of each.

On November 10, Dr. Charles S. Draper, Professor of Aeronautical Engineering, M.I.T., spoke on "Instrumentation in Aeronautics," describing the relationship of instrumentation to the aircraft industry and job possibilities in that field.

(*Continued on page 81*)

FLYING LST! GIANT NEW AIR TRANSPORT NOW BUILDING AT DOUGLAS!

Vividly the Berlin Air Lift reveals the need for high-speed, large capacity transport aircraft. And to meet this need skilled engineers and craftsmen at Douglas are now producing 28 giant, all-purpose C-124A transports for the U. S. Air Force.

Two and one-half times the size (by weight) of the famed Douglas C-54, this huge plane will carry a 50,000-pound load, and can transport military cargo 1,200 miles and return to base without refueling. Novel built-in nose ramp, similar to the famous sea-going LSTs, facilitates handling of heavy ground force equipment such as tanks, field guns, bulldozers and fully loaded vehicles.

It is expected that the C-124A will enhance in every respect the quarter-century reputation of Douglas for leadership in the design and construction of the world's finest, fastest and most dependable air transports.

DOUGLAS AIRCRAFT COMPANY, INC., SANTA MONICA, CALIFORNIA

DOUGLAS

News of Members

Donald R. Alger is General Manager, The Alger Theatres, Lakeview, Ore.

Milton C. Bergey, who was with Pilotless Plane Division, Fairchild Engine and Airplane Corporation, has been working as Design Engineer for Edo Corporation since last spring.

Charles Chin, who was graduated from Polytechnic Institute of Brooklyn with the degree of M.Ae.E., is a student at Harvard Graduate School of Engineering, Harvard University.

Paul Comisarow is now employed by the Bureau of Aeronautics in the Design Elements Division as an Aeronautical Engineer, Navy Department, Washington, D.C. He was with N.A.C.A. as Aeronautical Research Scientist in the Stability Division.

Thomas G. Cribb has been transferred from the Inspection Department to the Engineering Department in the Canadian Car & Foundry Company Ltd., Montreal. He is employed in the Weight & Balance Group as a Technician.

K. Derdiarian, who was Senior Engineering Draftsman for Pan American World Airways System, has been appointed to the position of Assistant Standards Engineer for the Atlantic Division, New York Airport Station, La Guardia Field, N.Y.

Harry W. Dolfi, former student at Harvard Graduate School of Engineering, is a Stress Analyst at Douglas Aircraft, Santa Monica, Calif., plant.

Robert M. Edholme, Chief Test Pilot for McDonnell Aircraft Corporation, made the first test flight at Muroc in new Air Force jet fighter, XF-88, built by McDonnell. He flew it for 15 min. in the initial flight.

Honeywell Representative: *William O. Boschen has been named regional representative of Minneapolis-Honeywell Regulator Company's aeronautical division. He will work with aviation companies in the New York area out of the division's East Orange, N.J., office. A native of Newark, Boschen is a graduate of Massachusetts Institute of Technology. He joined Honeywell last year, having been previously employed by Aviquipo, Inc.*

Ahmed Cemal Eringen is Research Assistant Professor at Illinois Institute of Technology.

Robert H. Essig, formerly with N.A.C.A. as an Aeronautical Engineer, is now Assistant Chief Engineer for Measuring Machines, Inc., manufacturers of compressor and turbine blade measuring equipment.

Dimitrius Gerdan, Chief Engineer of Allison Division, General Motors Corporation, forsees a turbo-powered transport of about DC-6 category as smallest that can be used domestically because of fuel consumption characteristics.

Howard Lee Goldston is engaged as Industrial Engineer at Leviton Manufacturing Company.

Arthur Graham is at Stanford University at Palo Alto as a graduate student. He was an Aerodynamicist with Douglas Aircraft, Santa Monica, Calif.

Ian A. Gray is Supervisor of Engineering, Canadian Pacific Air Lines Ltd., having been promoted from Service Engineer.

Charles L. Gruenberg, who was attending Oklahoma University, now is an employee at the Wichita, Kan., plant of Boeing Airplane Company.

Clarence S. Howell is in Tulsa, Okla., as an Assistant Engineer, Power Plant Group with American Airlines, Inc.

Paul G. Johnson is with Consolidated Vultee Aircraft, Ft. Worth, Tex., as Aerodynamicist B.

G. Lester Jones, one-time engineering and production manager of Sperry Gyroscope Company, has been appointed Chief Engineer of Lear, Inc. Grand Rapids, Mich.

Charles H. Kaman, 30-year-old inventor and President of Kaman Aircraft Company, describes the K-190 helicopter developed by his firm as "a truck, built to take a beating." The stripped-down model has flown more than 170 hours without a single part—blade, bolt or bearing—being replaced. Kaman has new Navy contract to furnish information on 'copter flight characteristics treating stability, control, and handling properties.

J. P. Layton was named Head, Field Rocket Group, The Glenn L. Martin Company, making pilotless aircraft. He previously was Research Engineer for Martin, having been with the company since January, 1946.

Don R. Learned is a Facility Analyst at Ford Motor Company.

Lt. Comdr. J. R. MacLachlan, U.S.N., has been assigned Power Plants and Propeller Liaison, Bureau of Aeronautics General Representative, Central District. He formerly was Chief Test Pilot, Flight Test Department, Naval Aircraft Factory Philadelphia.

D. C. MacPhail, formerly with the Royal Aircraft Establishment, Farnborough, Hants., England, has been appointed to the National Research Council, Ottawa, Canada.

Boeing Flight Test Chief: *John B. Fornasero, veteran test pilot who has headed up the Stratocruiser certification test program, has been appointed Chief of Flight Test Section for Boeing. In his new position he will be in charge of all engineering flight-test operations for the company, reporting to the Assistant Chief Engineer, N. D. Showalter, who held the flight-test post previously.*

William O. Meckley has been appointed Liaison Representative from the Institute of the Aeronautical Sciences to the Gas Turbine Power Division of the American Society of Mechanical Engineers.

Louis Montanino has moved from Jamestown, N.Y., to Niagara Falls. New job is Helicopter Engineer with Bell Aircraft Corporation.

John W. Myers, Vice-President of Sales, Northrop Aircraft, declared recently that the future may produce Flying Wings that will gross 500,000 lbs. and be capable of spanning the continent at costs as low as 3¾ cents a ton-mile. A 100-ton passenger-transport, similar in design to military Flying Wing, could carry perhaps 40 passengers plus 10 tons of freight nonstop from New York to Los Angeles in 5 hrs. 50 min. at a direct cost of about $16 per 200-lb. load.

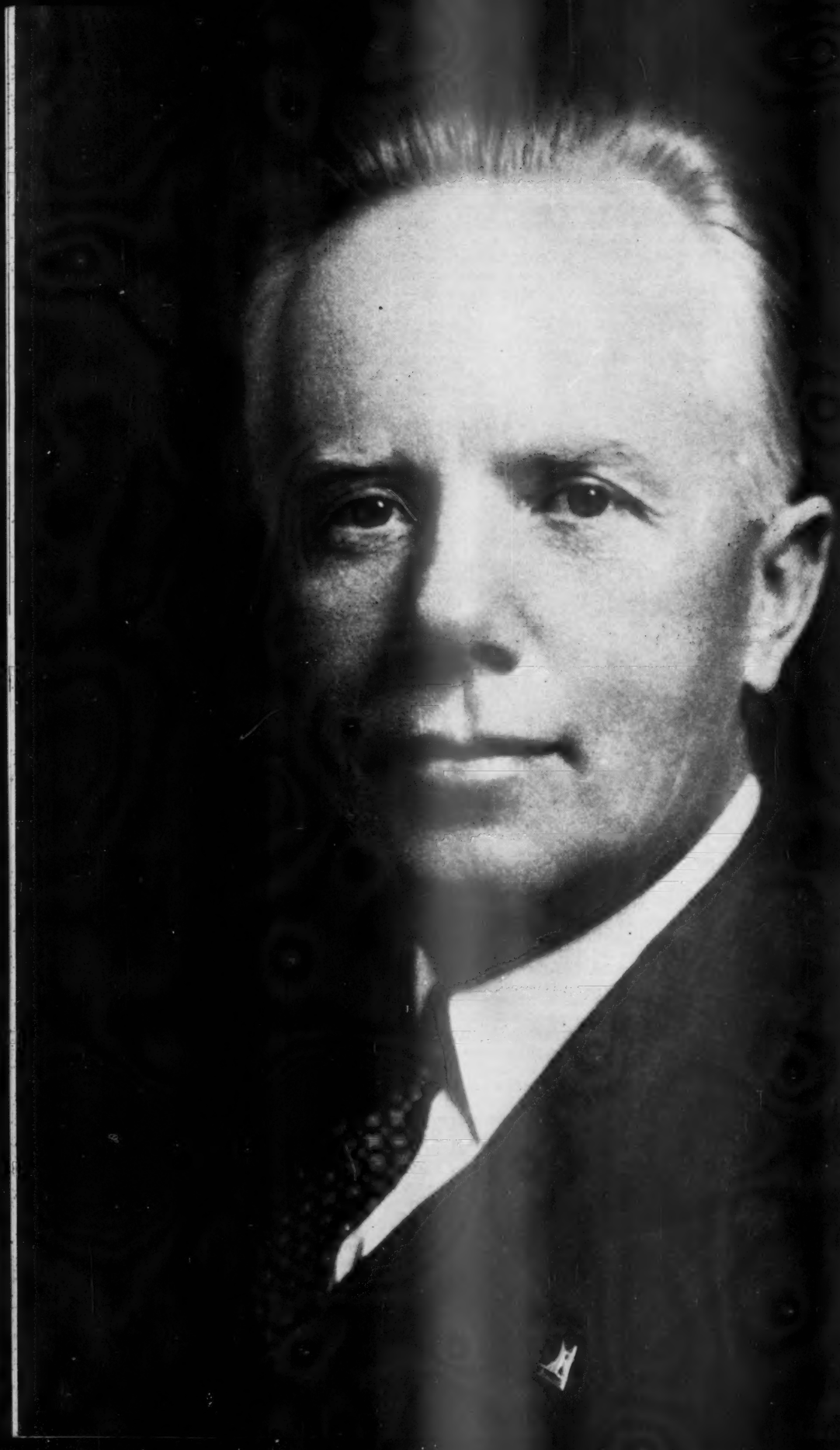
Donald H. Nelson, Jr., is Engineering Assistant, Aerodynamics. Lookheed Aircraft Corporation. He was Structural Engineer with Northrop Aircraft.

Edward M. Owen, former Chief Experimental Pilot, Chance Vought Aircraft, now is Sales-Engineer at Curtiss-Wright Propeller Division, Electronics Department, Caldwell, N. J. He is working on flight simulators.

L. G. Phillips is obtaining a familiarization with the oil business in the Phillips Investment Corporation and Phillips & Milam Oil Company. Previously he was Flight Test Engineer with Convair.

John W. Pocock has been admitted to partnership in the firm of Booz, Allen & Hamilton, business survey and management counsel company of New York, Chicago, and Los Angeles. He has been Account Manager for the firm.

(*Continued on page 82*)



Editorial

Hail, and Farewell!—

Shortly after this issue of the REVIEW appears we will welcome officially the new President of the Institute. He takes office at the Annual Meeting scheduled for January 24. No stranger to Institute affairs, William A. M. Burden is particularly well qualified to take over the helm for the coming year. A Founder Member, Benefactor, and long-time Member of the Council, he has an intimate working knowledge of Institute affairs, and the well-being of the organization is close to his heart. Officers, members, and staff pledge to him their fullest measure of cooperation as we embark on a program of ever-increasing activity for 1949.

And, fortunately, our "Farewell" to our outgoing President is not in any sense a final leave-taking. Many years ago, the Council in its wisdom decreed that Past-Presidents should serve on the Council for the year following their active term of office. In this way the Institute benefits from a continuity of policy that has tended to stabilize our operations and to keep us on a predetermined flight path.

As Jack Northrop turns over the controls to his successor, he deserves a hearty "Well Done" from every member of the Institute. As with most of the men who have filled the Presidential Chair, he has been exceedingly busy with his own affairs during his entire term. But at no time during the year has he failed to respond to the needs of the Institute for his attention. And this year in particular, with the two building projects on the West Coast, the demands for his time have been frequent and heavy. He shepherded both proposals through the contract stages, and, since the beginning of the active construction both in Los Angeles and in San Diego, he has been at the beck and call of the Building Committees for continuous advice and counsel. The fact that we now have two buildings approaching completion this year stems largely from the personal interest and drive of our 1948 President.

His interest in Institute affairs, however, has gone far beyond the securing of the buildings. A strong believer in the effectiveness of local, as well as national, activities, Jack has gone out of his way to visit I.A.S. Sections when he could and has added greatly to Section meetings here and there by lectures and by informal talks. In every possible way he has sought to make the Institute of more value to its members and to enhance its prestige.

We believe that in many respects the year just past will prove to have been the most critical in the Institute's history. It was a year of uncertainty for the aircraft industry. Although both the Finletter Commission and the Congressional Air Policy Board had reported their findings and made their recommendations early in the year, the pattern for the immediate future was far from certain until 1948 was well along. The strengthening of the industry in line with the recommendations of both groups is only now being effected. The real expansion will begin in the Spring of 1949.

But in spite of the uncertainties of the last 12 months, the Institute came through the year in excellent shape. Our membership is increasing. Our activities have reached an all-time high. Our financial position is sound. That these things have been accomplished stems in no small degree from the quality of our leadership. With such men as Northrop and Burden in command, the Institute's future is secure. We can do nothing but move ahead.

S. P. J.

John K. Northrop, retiring President of the Institute. His successor is William A. M. Burden, who will be inducted into office at the Honors Night Dinner, January 24.

General Fairchild*

on

"Air Force Headquarters Policy"

Excerpts from an address before the I.A.S. Fifth Annual Military Aeronautics Meeting, Dayton, Ohio, Nov. 18, 1948.

"THE WORLD SITUATION, generally, is so bad that it might seem incongruous to find anything made simpler instead of more complex by present conditions. Yet paradoxical as it might seem at first glance, the task of our military planners today is much simpler—more specific—than ever before in our peacetime history. Previously, we have had to prepare against unknown dangers, from unknown sources, in unknown locations.

"These conditions have naturally exercised great influence to confuse our thinking as to the types of forces we should make available and the character of the weapons we should provide those forces for use in some unknown situation that might possibly arise in the future. A natural result has been a tendency toward providing against all possible contingencies and going as far as possible toward producing all-purpose weapons. All-purpose thinking begets compromise in design, it begets complexity instead of simplicity, and it begets increased weight with consequent reduced performance.

"As I look over some of our past military characteristics and specifications, I can't help being reminded of the numerous equipments of the White Knight whom Alice encountered in the course of her immortal adventures, *Through the Looking Glass*. You will recall that he had all manner of things hung on the saddle of his war horse, including even a bee hive and a mouse trap.

" 'I was wondering what the mouse trap was for,' said Alice. 'It isn't very likely there would be any mice on the horse's back.'

" 'Not very likely perhaps,' said the Knight, 'but, if they do come, I don't choose to have them running all about. You see, it's as well to be provided for *everything*. That's the reason the horse has all those anklets round his feet.'

" 'But what are they for?' Alice asked in a tone of great curiosity.

" 'To guard against the bites of sharks,' the Knight replied. 'It's an invention of my own!'

"It is now a considered policy of our Air Force Headquarters to divest our war horses of their accumulated bee hives and mouse traps and even to make a valiant effort to get rid of the anklets, in spite of the fact that they may be our very own invention!

"To this end we have recently been convening weight reduction boards to pass on the equipment and characteristics of all models under procurement or currently projected. We will go as far as possible with present designs, although it is obvious that the real payoff of this Spartan policy will come when we create new designs from scratch, taking advantage of all the structural weight and fuel savings made possible by reduced equipment requirements.

"This program is one of the first results of the increased emphasis being placed upon requirements in Air Force Headquarters. We have recently brought in Brig. Gen. Carl Brandt as Director of Requirements. . . . He is well known. . . from his fine work as Commanding General of the Air Proving Ground Command at Eglin Air Force Base.

"We are presently in process of greatly strengthening the position and influence of this Directorate in Headquarters through increasing its relative importance by raising its Chief to the level of an Assistant to the Deputy Chief of Staff, Operations, and by reorganizing its efforts. Instead of the old divisions according to types of aircraft, the new divisions of this Directorate will be organized to cope with the integrated elements

* General Muir S. Fairchild, Vice Chief of Staff, U.S.A.F.

of our major problems, such as: air defense, strategic air offensive, air transport, and Army and Navy cooperation. In addition, there will be a division devoting its efforts to overall technical suitability. We believe this new organization will enable our people who determine and define our requirements in the fields of air defense, strategic bombing or air transport, for instance, to work more closely and intelligently with our top strategic planners in each of these fields. This close organizational relationship between our operational planners and our equipment planners should result in producing sound, realistic requirements for complete integrated weapons systems.

"For example, the solution of the problem of effective air defense involves far more than the production of a suitable fighter aircraft. In fact the very characteristics of what *is* a suitable interceptor fighter cannot be disassociated from considerations of aircraft warning systems, communications systems, air-borne radar systems, aircraft control systems, and all the other intricate aspects that go to make up the whole of an effective air defense system.

"It is our hope and expectation that, through this close relationship between strategic planning and equipment planning and because of the present clear-cut nature of the problems confronting strategic planning, it will be possible to set forth clearly and precisely the military characteristics and equipment essential in each weapon. Greater specialization in aircraft is not only unavoidable, but in overriding respects it is desirable. The all-purpose fighter no longer meets any of our needs satisfactorily. While the providing of special types for special purposes of a nonstrategic nature will subtract from our strategic capabilities, the subtraction will be obvious and measurable, and it will be less dangerous in the long run than reducing the performance of all strategic weapons to produce an all-purpose compromise.

"The circumstance of being able to foresee strategic requirements rather clearly and specifically makes possible a more realistic evaluation of the means that can reasonably be made available. Thus, there will be less tendency for us to shoot for the moon by propounding some improbable combination of characteristics that might be found useful, hoping thus to inspire someone to come up with an answer better than we had any right to expect. We believe that by closer consultation and mutual understanding in explaining our exact and specific needs, we can, with your help, insure that these specific needs will be met. Thus, the confusion of trying to meet all possible needs with all equipments will be avoided.

"Since our own strategic problems are now rather exactly definable, the Air Force intends to devote a major effort in the future to defining clearly those problems, deferring to science and industry a greater share in solving them. We feel that each of us, the Air Force and the industry, will do a better job in our respective fields if we avoid the overlapping that has been fairly common practice in our past efforts. In this connection, you may anticipate a reduction in the rigidity of certain requirements that have been imposed in the past.

"Even though we continue to simplify our strategic thinking and consequently to simplify the problems relating to equipment, we recognize that the solutions of modern equipment problems cannot be simple solutions. The complexity and cost of modern air weapons are appalling. However, all the more reason for us both to strive toward the desired goal of reduced complexity with its concomitant reduction in present alarming cost trends.

"I could not conclude these remarks without paying a deserved tribute, or acknowledgment, or perhaps I should call it a confession of faith.

"We of the Air Force are firmly of the belief that our nation may well be dependent for its very existence in the future upon the continued untiring and foreward looking efforts of you gentlemen present this evening and your colleagues throughout the country.

"The Air Force has been given the primary responsibility for strategic bombing. I do not believe it is too controversial to assert that strategic bombing is today generally recognized as our most effective weapon against any enemy great and powerful enough to threaten us by aggression. The Air Force also has primary responsibility for air defense, which is surely the nation's most important, as well as its most difficult, defense. It is only through the superior efforts of you gentlemen and your colleagues that the Air Force can be prepared to carry out its vital tasks in the future in a manner so superior to the capabilities of any enemy as to be the greatest possible deterrent to aggression and to assure the preservation of our way of life if aggression should occur.

"Whatever the future may hold for us, one point is clear. Our nation can continue to be successfully defended only through continued and increased emphasis on our one great advantage in strength; our superiority in understanding and employment of modern science and technology.

"It is obvious that there are in the world today forces with which we cannot compete in terms of man power and which are not susceptible to defeat by encirclement or blockade. We are confronted with areas far greater than our own and natural resources in many respects more complete. Our great and unchallenged field of superiority lies in engineering skills and in our advanced understanding and employment of modern science and technology. We cannot—we dare not—lose any part of that all-important advantage.

"If our country, our homes, our friends, our priceless freedoms are worth-while, then our most strenuous scientific and industrial efforts must also be worth-while for it is only by these means that we may with certainty assure the preservation of our way of life.

"Gentlemen, the task of aeronautical science and industry grows more challenging every day; just as the responsibilities of your Air Force grow heavier. Let us continue to press forward together!"

Psychological Aspects of Stick and Rudder Controls in Aircraft*

JESSE ORLANSKY†

Dunlap, Morris and Associates, Inc.

SUMMARY

This paper is an attempt to determine how airplane control systems may be designed to provide the pilot with optimal sensory information by means of pressure cues obtained from operating the stick and rudder. The present approach to the problem consists of an examination and evaluation of literature pertaining to:

(a) The maximum forces that may be exerted by a human pilot.

(b) Human reaction time insofar as it may be expected to cause delays in the pilot's response.

(c) The optimal design, placement, and manner of movement of controls.

(d) The optimal gradient of control forces.

Certain recommendations for aircraft control systems are discussed.

STATEMENT OF PROBLEM

IN THIS PAPER, an attempt is made to examine some of the psychological problems associated with the operation of an airplane. It is a recognized fact that the control of an airplane may impose requirements beyond those that can be met by a human pilot. Even in routine operations, it is desirable that the arrangement of the cockpit, the controls, and the instruments (as well as their influence upon coordination between crew members) be such as to provide an accurate and easy flow of pertinent information. This is construed to be the psychological consequence of the mechanical design embodied by a particular airplane. Attention is directed, in the present study, to some of the human factors associated with the stick and rudder controls as they might be found in a high-performance fighter-type airplane. Though not attempted here, similar treatment might well be accorded to the instrument panel, to the radio console, to the flight engineer's desk, and, especially, to the integration of duties by the crew members.

The handling of high-speed aircraft requires the control of enormous forces by the application of equal counterforces, only a part of which can be supplied by the pilot. Since aerodynamic pressures increase markedly with speed, while the pilot's strength is relatively fixed, some means must be employed to assist the pilot in moving the control surfaces on the newer airplanes.

Conventional control linkages permit the pilot to perceive some of the airplane's flight characteristics through position and pressure effects on the stick and rudder controls. These effects are called "stick (or rudder) feel," and pilots rely upon them in flying the airplane. "Stick feel" depends, in part, on the cues arising from the feedback of some fraction of the aerodynamic forces developed upon the control surfaces. Mechanical boosters introduce special "feels" on the controls caused by friction, time-lag, pulsation, inertia, and other attributes of the booster system. Thus, as the fraction of force supplied by the pilot diminishes, feel becomes more and more dependent on the operating equipment rather than on flight conditions. Some modern planes employ mechanisms with a booster-to-pilot force ratio of 10:1, (i.e., the pilot supplies only one-tenth of the required control force), while future designs may require ratios as high as 1,000:1.

At the present time, pilots have come to expect certain stick-feel effects as the control stick is moved to various positions at various speeds. Booster mechanisms may so modify this relationship that stick feel varies almost independently of control surface pressures. In one system, for example, displacement of the control stick is related directly to displacement of the control surface; stick pressure remains constant at a low value, thereby eliminating any possible differential pressure cues. Or, the stick may be used to initiate control surface motion, while the degree of stick deflection monitors the rate of change. In this case, again, the normal pressure and displacement cues are altered. "Normal" control feel may be re-established by artificial means but, to accomplish this, it would first be necessary to understand what is meant by "normal" control feel. Current specifications do not rigidly determine a standard control feel, and it can be shown that current airplanes actually differ in their feel characteristics.

An airplane may be flown without "normal" control feel, as evidenced by the operation of remotely controlled aircraft. However, it is not yet feasible to maneuver in this manner a fighter aircraft, as if in combat. Jet fighter pilots, 15 of whom were interviewed in connection with this project, indicate that there is time for only slight attention to the instruments during high-speed acrobatics in planes like the F-80 Shooting Star and F-84 Thunderjet. During maneuvers, these pilots maintain their primary orientation by reference to the horizon and stick feel, with secondary regard to three of the instruments: the Machmeter, yaw indicator, and altimeter. They regard stick feel as a particularly valuable cue because it is always

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† Ph.D.

available without distracting the pilot's attention from his target. A pilot upon whom is placed the tasks of navigation, communication, and aerology, in addition to flight control and combat, approaches the limit of his abilities. For such a man, a stick with feel is equivalent to a host of flight instruments.

Since current airplanes are not consistent in their control feel characteristics, present practice alone does not dictate a desirable standard for future aircraft. It would appear useful to examine several questions generally applicable to all airplanes regardless of their speed.

(a) What are the maximum forces that may be exerted by a human pilot?

(b) What delays may be expected as a consequence of the pilot's reaction time?

(c) Where should the controls be placed, and how should they move for most efficient manipulation by the pilot?

(d) What gradient of stick forces will provide the pilot with optimum pressure cues?

In this paper, the problem is approached by an examination of published information and by extensive interviews with jet plane pilots. The study indicates a direction for the experimental work which may be desirable to verify the present conclusions. Attention in this study is directed primarily to fighter aircraft equipped with conventional stick and rudder controls.

Evaluation of Human Capacities for Aircraft Control

(A) *The Maximum Forces That May Be Exerted by the Pilot.*

It is obvious that the maximum control forces required of a pilot must never exceed the limit of his strength. These forces are limited to the following maxima on stick-type controls:

elevator	35 lbs.
aileron	30 lbs.
rudder	180 lbs.

These values appear to be based on a study of two pilots carried out in 1936 by the National Advisory Committee for Aeronautics.[9] A comparable study for wheel-type controls were reported in 1937.[19]

(*1*) *Elevator Control Force.*—Fig. 1 is derived from data presented in the N.A.C.A. report. The two upper curves represent the maximum push-and-pull forces that may be exerted in the most favorable lateral position, which was right of neutral for these right-handed pilots; the two lower curves represent the maximum forces in the least favorable lateral position. It is clear that greater pull forces than push forces may be exerted in all hand positions except those close to the seat. The ability to exert a push or a pull force increases with distance from the seat. Accepting the two pilots as a representative sample, it would appear that pilots would always be able to exert the maximum allowable elevator-type force except where the hand is close to the body.

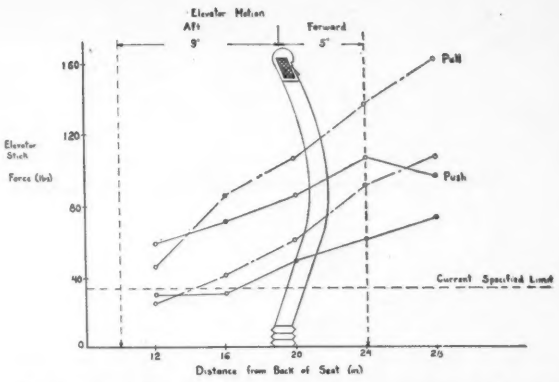

FIG. 1. Maximum push-and-pull forces exerted on elevator at various hand positions (lesser force of two pilots). The two upper curves represent performance in the most favorable, while the two lower curves represent the least favorable, lateral position (range ±8 in. from center). The limits of elevator motion in a standard cockpit and the maximum permissible elevator force fixed by specification (35 lbs.) are indicated.

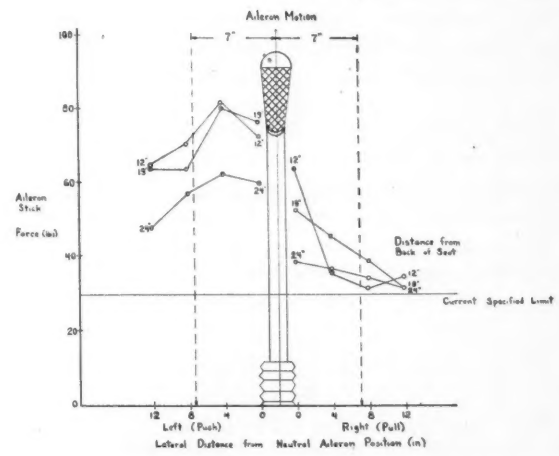

FIG. 2. Maximum aileron forces exerted at various hand positions by one pilot. The limits of aileron motion in a standard cockpit and the maximum permissible aileron force fixed by specification (30 lbs.) are indicated.

(*2*) *Aileron Control Force.*—The data for aileron forces are shown in Fig. 2. The right-handed pilot can exert greater aileron force to the left (i.e., push) than to the right (pull) of neutral, the ability decreasing with lateral and forward displacement. The maximum aileron forces that can be exerted are less than the maximum elevator forces and do not vary so much with changes in hand position. The data indicate the influence of hand position on the ability to exert aileron forces and show that performance decreases at extreme positions. Apart from aerodynamic considerations, they also suggest that right-handed pilots might find it easier to perform counterclockwise rolls and turns to the left than clockwise rolls or right turns.

(*3*) *Rudder Control Force.*—The N.A.C.A. data on rudder forces indicate that the design limit of 180 lbs.

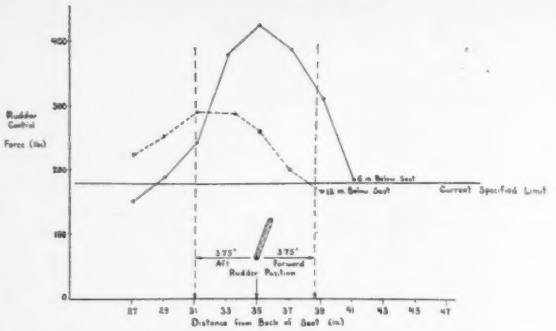

FIG. 3. Maximum rudder force (lesser force of two pilots) exerted at various foot positions with the rudder bar at two levels below the seat. The limits of rudder motion in a standard cockpit and the maximum permissible rudder force fixed by specification (180 lbs.) are indicated.

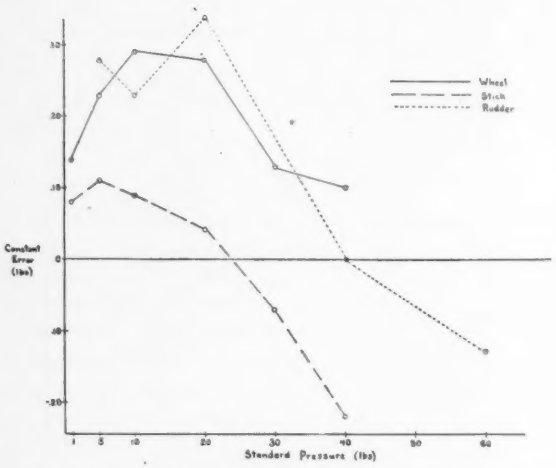

FIG. 4. Accuracy of performance in applying certain specified pressures to stick, wheel, and rudder controls.

can generally be exceeded, as based upon the maximum rudder forces exerted by the weaker of the two pilots. Fig. 3 also shows that rudder forces fall off sharply as the seat height increases above the rudder.

Taken together, these three graphs suggest the following conclusions:

(a) The force limits imposed by current design specifications are generally lower than the maximum forces that humans can exert.

(b) The permissible aileron forces approach human limits for this type of motion.

(c) There appears to be a reasonable margin between elevator and rudder forces and the human limits for these types of motion.

It can hardly be doubted that the standard or maximum allowable forces are based on an inadequate sampling of the pilot population. One consequence of this fact is that there is inadequate knowledge of the safety factor allowed by the present standards. Pilot acceptance of present control force standards might be interpreted as a demonstration of their validity; however, pilots often have endured undesirable practices without objection. Apart from the maximum allowable force, another requirement is that the actual force expenditure be optimum to minimize fatigue and to facilitate delicate control adjustments. The next section is devoted to this consideration.

(*B*) *Sensory Discrimination of Control Pressures*

Various control motions are required for take-off, maneuvering, and landing, and, as has been shown, the required forces should not be excessive. An important psychological question is whether these forces increase by magnitudes that permit the pilot to make his most sensitive adjustments. A pilot cannot detect changes of a few ounces in the pressure—i.e., "feel"—of the controls; nor, while exerting a force of 100 lbs., could he detect an increase of 1 lb. There is probably an optimum pattern of pressure increases which would furnish the pilot with a maximum number of discriminable cues.

This consideration relates to the Weber-Fechner law, a famous psychological generalization, first stated in 1834, on the perception of differences—i.e., human sensitivity. As Woodworth puts it, "in comparing magnitudes, it is not the arithmetical difference but the ratio of the magnitudes, which we perceive."[28] The significance of this generalization, insofar as it applies here, is that one should not expect a pilot to detect the same differences in pressure at all points in the pressure continuum. He might, for example, discern a difference between 5 and 6 lbs. (ΔI* equals 1 lb.), but require an increase from 15 to 18 lbs. (ΔI equals 3 lbs.) before he could again note a difference. That is,

$$\Delta I/I = k$$

where ΔI is the just discernible increase in intensity I and k is a constant. In the examples just given, $\Delta I/I = 1/5$ and $3/15$ and $k = 20$ per cent. Intensity perception is relative and not absolute.

An investigation of pressure discrimination has been carried out by Jenkins[15] at the Aero Medical Laboratory, Wright Field. A cockpit mock-up was prepared so that the accuracy of reproducing the various types of control pressures on stick, wheel, and rudder could be determined. The subjects were blindfolded and, after practice, were required to apply designated pressures on the controls. By this technique data were gathered on the accuracy and consistency of performance of 20 A.A.F. pilots and 13 nonpilots. No information was collected on discrimination of angular displacement of the stick or on a flight-simulating task requiring continuous adjustment.

The differences between the standard specified pressures and the averages actually attained were measured in pounds and called the constant errors. The closer a value is to zero constant error, the more accurate is the performance. The data show that pilots tend to overexert when trying to push (or pull) small pressures,

* ΔI represents the discernible increment in intensity or the just noticeable difference.

while they underexert for the larger pressures. One may observe in Fig. 4 (based on Jenkins' study) that more sensitive control is possible by means of the stick than by either wheel or rudder. At all pressures up to 30 lbs., the constant errors are least for the stick control, with wheel and rudder following in that order. This is more sharply indicated in Fig. 5, which shows relative accuracy as determined by the ratio of constant errors to the standard pressures. The lower the ratio, the more accurate the performance. The stick is, of course, the most accurate control agent among the three types considered, and its relative accuracy is fairly constant from 5 to 40 lbs.; no difference was found between the accuracy of elevator and aileron type motion; the relative accuracies of the wheel and rudder are constant from about 15 to 60 lbs., the largest value tested.

The following conclusions may be drawn from Jenkins' study:

(a) A pilot will be able to discriminate more pressure cues if stick pressure increases in a nonlinear (rather than linear) manner with respect to its independent variable, such as stick displacement or airplane speed.

(b) Control pressures should occur over a wide range in order to provide the pilot with as many perceptible pressure differences as possible.

(c) When control pressures are low, they provide poor cues. They should rarely be less than 5 lbs. This requirement would also appear to be necessary to overcome the masking effect due to friction. Merely resting the hand on the stick results in some pressure because of the weight of the arm; the same is true for the rudder pedals, where the average pressure due to the weight of the feet was found to be 7 lbs.

(d) When attempting to exert a small force, the individual tends to apply a greater force than is required. Conversely, he underexerts when a large force is required. There is, therefore, an optimum range for control forces which may be estimated as 5 to 30 lbs. for elevator and aileron and 7 to 60 lbs. for rudder.

(e) Pilots appear to be more accurate than nonpilots in these tests. The number of flying hours and body weight were not related to accuracy. Performances improved with practice and with knowledge of results. When a light force immediately follows a heavy one (or vice versa), there is some evidence that the accuracy of a performance is adversely affected.

Pilots' opinions concerning the stick forces they have exerted in flight show that they are apt to be inaccurate judges. Thus, Gough and Beard[9] report that two experienced test pilots made estimates that were found to be in error by as much as 50 per cent when checked against instrument records. They were most accurate in reporting pressures of about 10 lbs.; they exerted more force than they thought they did in the case of small values and less in the case of large values. De Beeler[3] showed that pilots vary considerably in reproducing in a mock-up the rate of motion they would use to pull out of a dive. The present author has examined

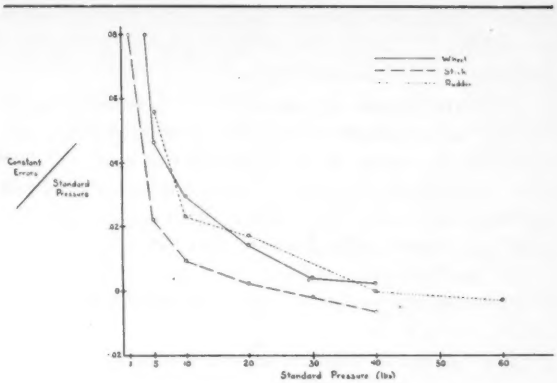

FIG. 5. Relative accuracy of performance in applying pressures to stick, wheel, and rudder controls

records that show that pilots actually exerted only 40 to 50 lbs. during flights on which they reported they had exerted 100 lbs.

A number of investigators have examined the factors that influence accuracy in the operation of hand controls. Their interest has generally been directed at manual controls for tanks and guns, but some of the findings are applicable to the present topic. Craik and Vince[5–7] report that friction of approximately 2 lbs. in a hand control is desirable to eliminate the effects of body sway, hand tremor, jolting, and vibration to protect the operator against involuntary sagging of the arm, as well as to smooth out control movements. Performance was more accurate when visual observation of an instrument display was permitted, in addition to detection of the pressure cues.

For precision of adjustment, Hick[11] advises no control motion below the limits of 2-lb. pressure and 2-in. movement. His experiments, as do those of Craik and Vince, also show that small forces and distances are overestimated, while large forces and distances are underestimated. Errors of 5 to 15 per cent are found in the manual exertion of force.[13] A pressure-gradient with velocity led to an improvement in handle-winding performance. According to Hick,[12] friction (up to 4 lbs.) at the handle reduces average error by about 15 per cent under conditions of jolting but is unfavorable when no jolting is present.

One may conclude on the basis of these studies that:

(a) The perception of changes in pressure, such as observed in airplane control systems, is not an absolute ability but is relative to the level of pressure at which the change occurs. The increments of stick pressure in response to changes in stick displacement or speed should be geometric rather than arithmetic in order to furnish the pilot with the maximum number of discriminable pressure cues.

(b) The pilot is most sensitive to pressure differences when controls are operated against a moderate work load. The optimum range of this load for accuracy and consistency of performance is of the order of 5 to 30 lbs. for stick and 15 to 60 lbs. for wheel and rudder

controls (higher values were not tested for the two latter controls). Higher loads would probably increase fatigue to an undesirable degree.

(c) Some friction on the controls is advantageous in eliminating the effects of hand tremors, jolting, and vibration because it tends to smooth out motion. The level of desirable friction on hand control is reported variously as 2 to 5 lbs. While there are no data on desirable rudder pedal friction, there is a hint that it should be of the order of 7 lbs., as judged by the average pressure exerted by the resting weight of the foot.

(C) The Position of Controls and the Direction of Motion

The advent of power-operated controls permits the design of controls in any size, shape, and position deemed desirable for ease of performance. An evaluation of novel type controls may be recommended, but it is beyond the scope of this paper. However, attention should be directed to the effect upon performance of such factors as direction of movement, size, shape, and position of the controls.

Considerable anthropometric data are now available on the population likely to operate airplanes,[8, 22, 23] tanks,[1] and similar military equipment. The dimensions of the standard cockpit are based on such information. Recently, King, et al.,[18] measured the functional reach of 139 young males, of whom 79 were Navy pilots. He found that the stick and rudder in the standard cockpit could be manipulated to their limits of motion by 97 per cent of that population, but 3 per cent would have difficulty.

It may be expected that the precision of linear adjustment, such as required on stick and rudder controls, varies somewhat with the position of the hand and foot. King remarks that "the precision of movement of the hand and fingers decreases as an unsupported arm is extended." None of the available investigations, however, gives quantitative measures of the accuracy of manual (or pedal) control motion for various positions and distances similar to what Jenkins has done for control pressures. Ideally, such investigation would reveal the distance through which the hand (or foot) must move, at various extensions and under various loads, before a just noticeable increment occurs.

Vince[25] shows that the direction of control motion should be similar to the expected direction of its effect, especially for performances requiring rapid adjustments. This finding, which is confirmed by Warrick,[26] is of special applicability in airplanes, where rapid adjustments of controls are so frequent; with further development of high-speed aircraft, the importance of relating direction of control motions to direction of effects will increase tremendously.

Grether[10] tested the relative efficiency of several types of aircraft control motion in a simple pursuit task. The subjects (24 nonpilots in one experiment, 36 rated pilots in three other experiments) were required to move each control so that a pointer, randomly activated, returned to its reference mark. The efficiency of performance was measured by a clock that cumulated the time intervals during which the pointer was kept within the reference mark. Five control motions—i.e., rudder, stick aileron, wheel aileron, stick elevator, and wheel elevator—were studied. Various comparisons were made of such conditions as equal or unequal extent of control motion and angle of knee or arm flexion on the controls. Grether concludes that:

(a) Hand controls (stick or wheel) are better than foot controls (rudder), for equal and unequal extents of movement.

(b) Elevator movements (fore-and-aft) are slightly better than aileron movements (lateral or rotary) on stick and wheel controls.

(c) The wheel and stick controls yield approximately equal efficiency for aileron and elevator type motion.

(d) There are differences in comfort but not in efficiency on tests performed under average leg and arm angles of 105°, 120°, and 135°.

One study[14] employed 18 pilots to investigate the effect of offsetting the stick and rudder controls from their normal central positions. There is a strong tendency to pull the controls back to a laterally symmetrical position, while fore-and-aft motion does not appear to be affected. Control motion is most accurate when the position of the hand is at normal elbow height, and hand tremor increases appreciably when the hand is held more than 8 in. above or below the level of the heart.[5] When the operator can observe visually the effect of his manipulations, his accuracy of control is greater than when he is dependent on kinesthetic cues alone.[2]

The shape of a handle affects the ease of control of machines and tools, but no studies are reported on the preferred shape of an airplane control stick. A shift from a round knob to a pistol-grip control improved by about 8 per cent the tracking, ranging, and triggering performance on the B-29 pedestal gun sight.[16] The diameter of a hand grip should be approximately 1.5 in. and should provide friction (e.g., be rubber covered) to facilitate the maximum exertion of force.[21]

To summarize the studies reported in this section, the following facts appear to be known with reasonable certainty:

(a) Hand controls are superior to foot controls. There seems to be no reason to prefer wheel over stick control, as judged by efficiency of performance in simple tasks. Fore-and-aft hand motions can be made with slightly greater precision than right and left or rotary hand motions.

(b) Conventional controls should be placed symmetrically with respect to the pilot, and the hands should be at elbow height. No penalty seems to be involved if the pilot adjusts his controls for personal comfort. The shape of controls affect efficiency of performance, and the guiding principle seems to be to shape and place the controls for maximum convenience of grasp.

(c) Full information is not yet available on the accuracy of hand and foot motions of the type used in airplane control. Data are required particularly for various conditions of pressure load. The best present estimate is that linear increments of about 15 per cent may be detected in the linear displacement of hand-operated controls under constant load conditions.

(D) Reaction Time and Rate of Motion of Controls

(*1*) *Reaction Time.*—There are many studies that describe the conditions that affect the time required to perceive and respond to a stimulus.[17, 28] Reaction time is often measured in laboratory situations that require a minimum of movement, such as may be entailed in pressing or releasing a telegraph key with one finger. The basic finding in such studies is that the reaction time is influenced by many variables, among which may be included the sense organ stimulated, the intensity and duration of the stimulus, the motor response involved, the subject's readiness to respond, the complexity of the task, and the subject's age. The aircraft designer should know that the shortest reaction time generally reported is of the order of 0.120 sec. to sound, 0.140 sec. to touch, and 0.165 sec. to light. These times increase with the complexity of a task, and 0.600 sec. is a fair estimate of the time required for such a response as applying brakes to a car after perceiving the cue. An early experiment in a cockpit mock-up showed that reaction time on a control stick averaged 0.200 sec. with a freely moving stick and increased to 0.600 sec. with a loaded stick.[29] While a simple reaction will usually require about 0.200 sec., a reaction involving discrimination and judgment necessarily will take more time. The consequences of such delay may be clear upon reflection that within 0.600 sec. an airplane may travel 88 ft. while landing at 100 m.p.h., and 733 ft. at 500 m.p.h. in the air, and that these speeds are often surpassed at present. The effects of such influences as anoxia, fatigue, and drugs, which prolong reaction time, may be examined in McFarland's book.[20]

(*2*) *Rate of Motion of Controls.*—Once the response is initiated, the speed of hand motion is a function of the work load and the direction of effort. As the stick force per unit displacement increases from 0 to 33 lbs. per in., there is a decrease in the rate of stick motion from 75 to 23 in. per sec. when pulled and 105 to 33 in. per sec. when pushed (minimum rates of 9 pilots).[3] The rate of push motion exceeds the rate of pull motion. One study[29] finds a maximum elevator pull at the rate of 63 in. per sec. when all conditions of load from 10 to 190 lbs. are averaged. The slowest rate occurred for two subjects at the maximum load.

Flight tests on an F8F-1 airplane[30] show that for approximately equal distances of stick travel (6 to 8 in.) the rate of motion dropped markedly from 52 to 10 in. per sec. as the maximum load increased from 35 to 97 lbs. Even though the pilot tried to achieve this motion within 0.200 sec., the actual time for the complete response increased from 0.160 to 0.750 sec. as the maximum load increased from 35 to 97 lbs.

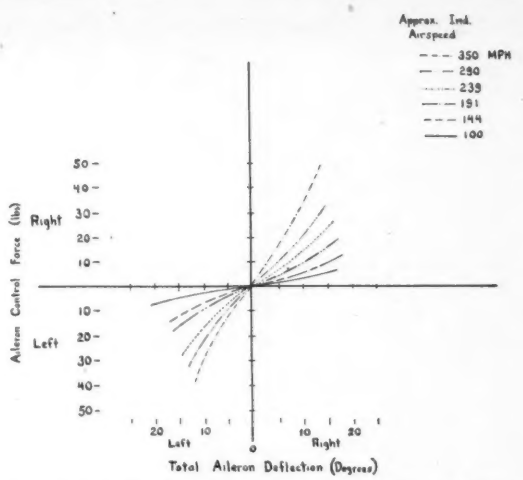

FIG. 6. Variation of aileron force with total aileron deflection in the cruising condition on the XP-51 airplane.[27]

While the data are admittedly scanty, it appears likely that the rate of control stick motion decreases as the load increases. Pull rates of the order of 50 in. per sec. appear reasonable at a load of 35 lbs. (maximum elevator limit according to specification). Rates as high as 75 in. per sec. under lesser loads, and as low as 10 in. per sec. under 100-lb. loads, may be expected. Such evidence as exists suggests that the rate of push motion exceeds the rate of pull motion by about 25 per cent. No data on rate of rudder motion are available.

PSYCHOLOGICAL ASPECTS OF HANDLING QUALITIES

Stick feel may be observed in terms of the relationship between control stick deflection and control stick force under various conditions, such as with speed and center-of-gravity position. Current specifications on control stick feel are expressed in general terms, which permit considerable latitude in design. Thus, it is required that control stick pressure increase with stick deflection from neutral, but the magnitude and regularity of the increase are not specified. Control force must also increase with acceleration at a rate of at least 3 lbs. per *g* and not more than 8 lbs. per *g*. It should be clear, however, that 3-lb. increments cannot warn the pilot so effectively as 8-lb. increments. As a matter of fact, the specifications allow such leeway that the relationship between stick force and stick displacement may be linear or curvilinear. The results of the interviews with jet plane pilots and aeronautical engineers show that they believe a linear relationship to be most desirable.

Fig. 6 shows the relationship between aileron deflection and control force at several air speeds in the XP-51;[27] Fig. 7, for the rudder in the F4U[24]. Such curves, which are based on flight-test data, show that there are families of curves in which control forces increase in a nonlinear fashion with deflection of the con-

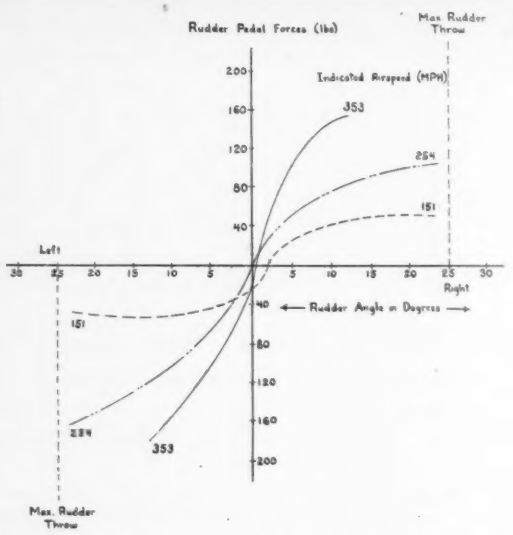

FIG. 7. Variation of rudder pedal force with total rudder angle in the F4U-4 airplane.[24]

trol surfaces. It may be observed that the curves in the two figures differ from each other in their shape and that this must make a difference in the respective control feel characteristics. The following discussion is concerned primarily with two aspects of these curves: (1) control displacement versus control force at any air speed and (2) the variation of control forces for any displacement at several air speeds. Other gradients, such as between control force and g, and between control force per g and center-of-gravity position, also influence the character of the control feel.

Consider, first, the relationship between control force and stick position at some particular air speed, which, since we are concerned with fighter airplanes, may be the normal maneuvering speed. Fig. 8 is a conventionalized drawing to demonstrate three possible relationships between displacement and force at one air speed. Curve A represents a relationship of the type existing for rudder on the F4U-4 at 353 m.p.h.;[24] B, for aileron on the XP-51 at 290 m.p.h.;[27] and C, for aileron on the P-47N-1 at 250 m.p.h.[10]

According to curve A in Fig. 8, initial stick deflections develop large increments in stick force, while the magnitude of the increments decreases with further stick deflection. This is conducive to strong self-centering characteristics upon even slight deflection. However, the normal work load would be relatively high, and this might lead to unnecessary fatigue. Furthermore, since there is no rapid peaking of forces at extreme deflections, there is no warning to the pilot that he may overstress the airplane. The shape of this curve is contrary to the nature of human sensitivity.

Curve B represents a linear relationship in which stick force is directly proportional to stick deflection over the entire range. This is the form often thought to be most desirable, and, indeed, there should be no *a priori* objection to it. The deviations from a linear relationship observed in Figs. 6 and 7 are often difficult to avoid because of complex aerodynamic factors. In a strictly linear relationship, self-centering characteristics may not be strong near neutral, and there may not be a marked warning of an approach to critical conditions.

Curve C bears a strong resemblance to the relationship that, as has been shown in this paper, describes the human ability to make discriminations of intensity. Since intensity discrimination is a relative and not an absolute ability, the *increasing* amounts of pressure which occur with variation in stick displacement would be experienced as apparently equal steps. Thus, one might expect curve C to provide maximum sensitivity to differences of pressure. This curve might prove deficient at positions near neutral where self-centering characteristics would be weak. However, control forces would be light over most of the stick deflection range.

An ideal force curve should satisfy problems that arise in the three areas identified in Fig. 9. This is a conventionalized curve and the straight lines, their

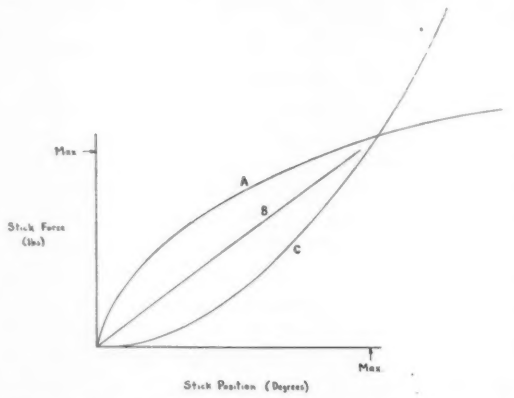

FIG. 8. Conventionalized curves to demonstrate three possible relationships between stick force and stick displacement at one selected air speed.

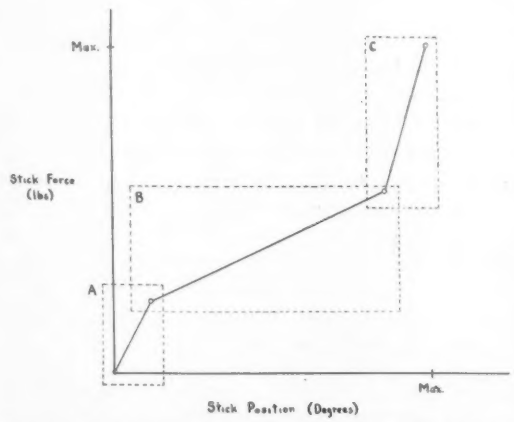

FIG. 9. Critical areas on a conventionalized stick force versus stick displacement curve for one selected air speed. The area designated as A represents the requirements of self-centering characteristics; the B area represents light stick forces over most of the range; and the C area represents warning of extreme conditions.

lengths, and the points of inflection are intended only for purposes of discussion. The A band represents the area of initial stick deflection. Good stick feel requires that there be strong self-centering characteristics, even with slight stick displacement from neutral. In practice (as revealed in interviews with pilots), the friction generally inherent in control systems masks self-centering and diminishes the feeling of confidence which the pilot gets when the stick is "in the groove." It is clear that slight stick deflection should produce forces that will exceed the control friction limits permitted by present specifications. The amount by which stick force exceeds control friction should be a discriminable magnitude. Jenkins[15] has reported that accuracy of performance is poor for stick pressures under 5 lbs. (15 lbs. for rudder), and this would be a first approximation to an upper limit for the A segment of the curve.

The B band represents the area within which most maneuvering occurs. There are two major requirements in this area: (a) stick forces should be as light as possible to reduce pilot fatigue; and (b) maximum sensitivity of control should be achieved—i.e., when constant stick deflection increments produce constant pressure *feel* steps or just noticeable pressure differences. The preferred shape of the curve in the B area of Fig. 9 should be similar to that of C in Fig. 8. Pressure increments that produce equally noticeable steps are of the order of 10 per cent.

Area C in Fig. 9 represents the problem of extreme stick deflection. In this area stick forces should peak rapidly to warn the pilot that he is in danger of exceeding the structural limitations of the airplane. This information is transmitted only when the force increments at limiting stick deflections are great enough to be detectable. The limit currently imposed by requiring that forces in this area approach the maximum that can be exerted by a pilot is not sufficiently reliable because maximum strength varies among pilots. Secondly, present limits may occasionally be exceeded, with unfortunate results, during the emotional stress of combat. The general requirements of area C are satisfied by continuing the curve already considered desirable for area B but increasing somewhat the increment ratio, $\Delta I/I$, in the C area. A smoothed curve that conforms to the criteria discussed here is illustrated in Fig. 10. While the opinions of the pilots and engineers who were interviewed cannot be substituted for experimental data, one must report that they all agreed, without any reservations, that the stick force curve, as described in Fig. 10, may prove effective.

Since control forces are related to, and increase with, speed, the single curve of Fig. 10 must be surrounded by a family of curves representing various speeds. If control stick feel should yield information on speed (and approach to a stall), these curves must be distinguishable from each other. These curves cannot all be psychologically equal. The best curve—i.e., the one providing the largest number of discriminable pressure steps—should primarily be detailed to the most important tactical requirement. In a fighter this might well be the maneuvering speed, while in a transport it would probably be the cruising speed.

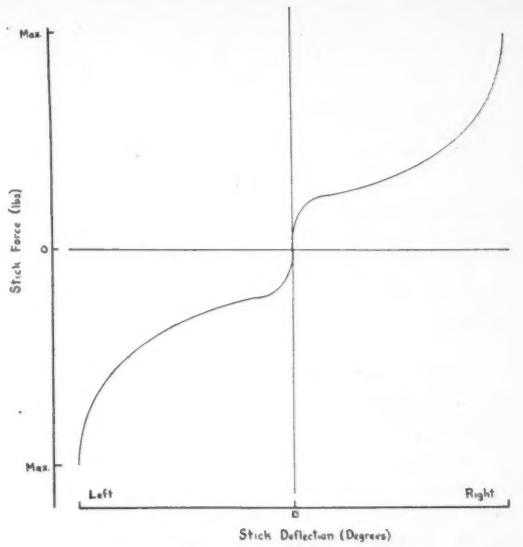

FIG. 10. Demonstration of a stick force versus stick displacement curve that would satisfy certain conditions proposed in the text. This curve would be true for one selected air speed.

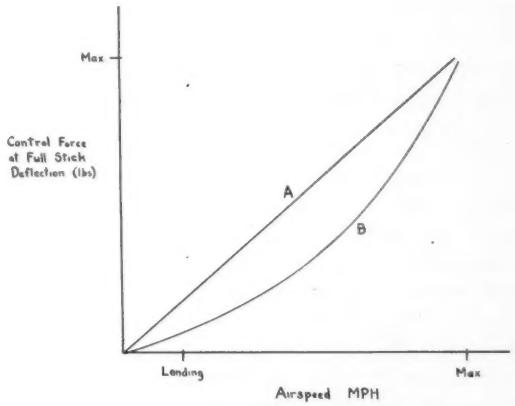

FIG. 11. Two possible relationships that may exist between control force at full stick deflection versus air speed.

The problem may be illustrated by reference to Fig. 11, which is a demonstrative plot of the control force at full stick deflection versus air speed. The ordinate represents control force (at full stick deflection) with a maximum set by the specifications for stick and rudder. The abscissa is related to the flight characteristics of the airplane under consideration. One airplane may land at 60 m.p.h. and have a top speed of approximately 180 m.p.h; thus a factor of 3 (180/60) expresses the range between its lowest and highest speed. New airplanes may have a range of 100 to 600 m.p.h. or a speed range factor of 6. Since control forces are limited by an acceptable maximum, as for example 35 lbs. in the case of elevator motion, the range between minimum and maximum force must serve various speed ranges. In other words, the control force gradient in lbs. per m.p.h.

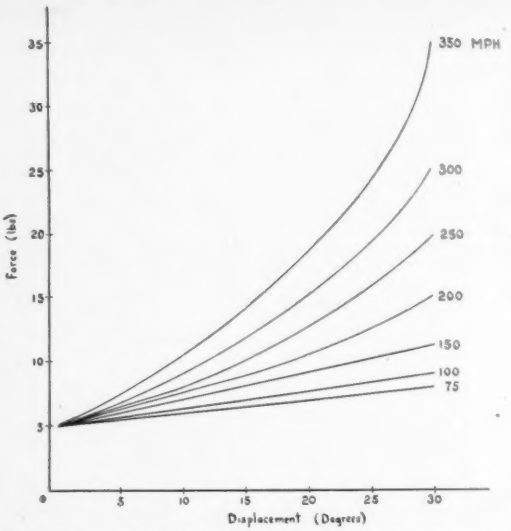

FIG. 12. Simplified family of curves relating stick displacement, stick force, and air speed for a particular airplane, in accordance with a formula given in the text. The maximum air speed is assumed to be 350 m.p.h., maximum control force is 35 lbs., and maximum stick deflection is 30°; the stalling speed is taken as 75 m.p.h. and the minimal control force is 5 lbs.

(i.e., the change in force per unit speed) becomes smaller as the speed range increases. This gradient, which is of the order of 0.175 lb. per m.p.h. for training airplanes, drops to 0.05 for some planes and has been calculated at 0.03 lb. per m.p.h. for some new types. The problem confronting the designer is whether this gradient, such as 0.03 lb. per m.p.h., should be spread equally over the speed range as in curve A of Fig. 11, or otherwise as in curve B. The reasoning in this paper would lead to a preference for curve B, the shape of which is dictated by the nature of the human ability to discriminate pressure differences. Fig. 12 demonstrates a possible family of curves for a given airplane showing the relation between stick displacement, required force, and speed. The curves are in simplified form because no adjustment is made to allow for the overcoming of initial friction except that all of them start at 5 lbs. Curves for other speed ranges may be computed from the following formula,* which was used:

$$d = k\ (\log f - \log f_1)\ V_1/V$$

where

d = displacement in degrees
f = control force in lbs.
f_1 = minimum force
V = air speed in m.p.h.
V_1 = stall speed
k = a constant defined by setting f, d, and V to permissible maximum

These curves are one of several which may be suggested; but before any final curves are adopted, they would have to be validated by flight tests.

One important problem is the relation between elevator control force and the weight and balance of the airplane. The usual situation is one in which stick force per g decreases as the center-of-gravity position shifts rearward. Another problem is how to ensure the continued effectiveness of the control surface in producing such desired responses as a specified rate of roll, maximum lift coefficient, and directional stability over the entire speed range. These are primarily aerodynamic problems, but their solution and standardization would go a long way to simplify such psychological problems as coordination of the controls for smooth flight and consistent flight characteristics for various types of aircraft.

It should be pointed out that aircraft control is possible, though not necessarily desirable, without any control stick feel at all. An extreme instance is the awkward means by which radio-controlled airplanes are flown. The "pilot" operates one or more toggle switches in a "bang-bang" system, so called because one flick on a switch may cause the airplane to climb while two flicks may cause it to descend. There is no feedback of the aerodynamic forces. Similarly, the manual adjustments by which maneuvering flight may be accomplished with a gyroscopic autopilot do not supply feedback forces and are different from those required on a normal control stick. While flight may be controlled by such means, and contemplated push-button schemes promise just this for the future, the real question is whether such methods are adequate for all purposes.

The issue may be a minor one for transport-type aircraft, where the maneuvering requirement is negligible and where feel may be desirable only for purposes of landing. In jet fighters, however, the pilots report an almost complete reliance upon stick feel (and a view of the horizon) during combat maneuvers, with an occasional reference to the Machmeter and yaw strain gage. Their experience leads one to the conclusion that some stick feel is highly desirable.

The study of control systems should not be limited to conventional forms such as the stick, wheel, and rudder. The innovation of booster systems implies that future controls may be of any size or shape and that they may be placed in any location. Preliminary investigation should collect information on the various principles of control motion which have been proposed and flight-tested, not neglecting those for the prone position. One should be careful to guard against the well-known tendency to favor those techniques to which one has become accustomed. In the event that new control systems may be proposed, the important matters for psychological evaluation are: which type (a) permits the most precise flight control, (b) best facilitates learning, and (c) may be operated with the least fatigue. In doing so, one should not be deterred by the fact that some of the new proposals may appear to be unconventional. An adequate test of various systems, according to their suitability as measured by the human

* This formula was suggested by Dr. John D. Coakley of Dunlap, Morris and Associates, Inc.

factor, may point the way to significant progress in a field whose main emphasis has often disregarded the very individuals it attempts to serve.

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Application of Servo Systems to Aircraft

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North American Aviation, Inc.

(I) Introduction

Present and proposed aircraft steering, navigating, and control systems are largely possible because of the development of "intelligent" machines. Many of these systems with "brains" and "nerves," as well as "sinews," are even now trusted servants of the pilots, engineers, and traffic controllers who operate our commercial and military aircraft establishments. Examples are shown in Fig. 1. distributed throughout an aircraft and its ground control equipment. They are variously called automatic pilots, automatic engineers, propeller synchronizers, automatic-pitch controllers, automatic navigators, automatic approach and landing systems, and control actuator boosters.

As aircraft become larger, faster, and more complex, we may expect the need for automatic pilots, automatic engineers, and automatic navigators to increase. Where the primary use of an automatic pilot today is to stabilize the aircraft and maintain a desired heading, developments now under way forecast the time when an aircraft can, if the pilot desires, take off, climb at an optimum rate, fly at an optimum speed over any desired course, approach its destination, and land in a crowded traffic pattern without any assistance whatsoever from its crew. Furthermore, such a flight will be performed more rapidly, safely, efficiently, and smoothly in all weather conditions than can presently be accomplished by human pilots under the most ideal conditions of weather and traffic. This will leave the crew free to double check the operation of the aircraft, fraternize with the passengers, and make emergency decisions.

We could continue prognosticating the wonders of the age of flight which will be born out of the marriage of aeronautical science with the science of automatic control. However, the purpose of this paper is to be informative rather than clairvoyant. Therefore, the discussion that follows will attempt to explain the basic ideas of a servo system, translate much of the "mumbo-jumbo" of the present-day servo cult into somewhat less mystic English, explain briefly present popular methods of design, their pitfalls and their limitations, and, finally, show the probable trend of future developments. Consequently, its only contribution will be in an emphasis of practical factors sometimes overlooked and the brief mention in the last section of an idea for combination open cycle-closed cycle systems which, to the writer's knowledge, has never been published previously.

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* Aerophysics Laboratory.

(II) Basic Ideas and Definitions

(A) The Automatic Pilot As an Example of a Servo

(*1*) *Definition of a Servo.*—The word "servo" has come to be used to denote a servomechanism or a servo system. It may be defined as "A combination of elements for the production of motion in which a source of power is controlled by the difference between an input signal and a specified function of the output motion in such a way that the output tends to be a desired function of the input for a specified repertory of input signal variations with time."

(*2*) *Introductory Remarks.*—Servomechanisms and servo systems may take a great variety of forms. Several have been mentioned in connection with the control of an aircraft. Fortunately, these devices and, in fact, all servos are more or less "brothers under the skin," so that it is only necessary to dissect one in order to get a good idea of the secrets of the whole breed. Accordingly, let us select the automatic pilot for detailed scrutiny, with the faith that an understanding of its intricacies will be readily applicable to many other servo problems.

(*3*) *Comparison of Autopilot and Human Pilot—the Basic Block Diagram.*—We begin by studying how a human pilot keeps an aircraft on course and right-side-up in turbulent air and use this as a model for our autopilot functional block diagram. The human pilot is part of a series of events whose final outcome is *motion* of the aircraft. The important factors involved in a human pilot's maintaining a prescribed pitch attitude of the aircraft are sketched in Fig. 2, and a corresponding but purely functional diagram that defines an autopilot is sketched in Fig. 3.

Evidently, the problem begins with a *desire* on the part of the pilot to climb the aircraft at a prescribed angle. This desire is largely independent of other parts of the system, yet it is one of the *two* factors that determine the moves and countermoves of the other actors in the drama. The other factor is the aerodynamic disturbance, or gust. So, Fig. 3 starts with an *input* corresponding to the pilot's desire for a given pitch attitude and a *load disturbance* arising from rough air.

Next, the *result* of a compromise between the pilot's desire and the disturbance is some pitch angle of the aircraft. Consequently, this appears in Fig. 3 as the *output*.

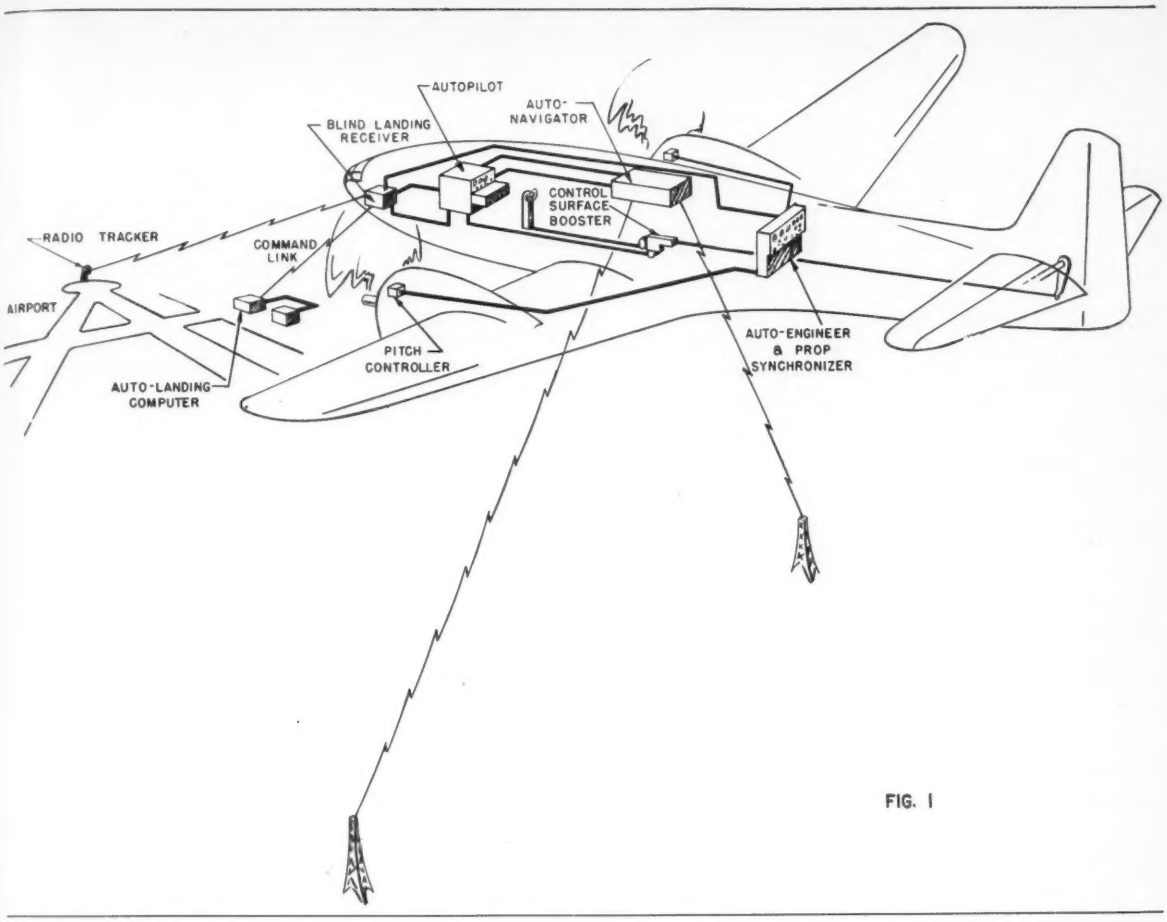


FIG. 1

The pilot's eye and brain *detect* any error or difference between the desired and actual pitch angles. Evidently, a corresponding element in Fig. 3 must be an error *detector* into which feed both the input and output and out of which comes the difference. For an autopilot, such a detector is usually a freely gimballed, vertically slaved gyroscope. A *pick-off* corresponding to the pilot's eye measures the relative orientations of the aircraft and a gyro gimbal. Sensitivity of this pick-off corresponds to the resolving power of the pilot's eye.

The detection of an error now sets up a chain of reactions in the pilot's *brain* and nervous system leading to a motion of the joy stick and, hence, the elevators. This imposes a pitching torque on the aircraft which changes its angle of attack and causes it to rotate and translate depending on its moment and lift coefficients, its pitch moment of inertia, and its mass.

We now investigate how *much* motion of the elevators should accompany an error of a specified size and history. Here we are again guided by the human pilot. A human pilot develops an ability to fly an airplane by experience. He learns what responses of his craft may be expected to a variety of control motions under different flight conditions of altitude, air speed, and load. He depends heavily, whether knowingly or not, on the fact that the very inertia that makes it impossible to correct attitude errors instantaneously also prevents their sudden generation, for the only disturbances encountered make themselves felt as forces (or moments) and, therefore, as angular or translatory *accelerations* requiring *time* to become changes in position. We also find, in general, that a larger disturbance requires a large control effort to overcome it, whereas a small disturbance is better handled more leisurely. In other words, it is desirable to have a rough correspondence between the magnitude of the error and corrective action. Furthermore, not only the size of the error but the rate of its correction affects the optimum control surface motion.

We have evidently been considering functions of the pilot's *brain*. It is this element that interprets the nerve stimuli from the eye and generates the muscular reactions that control the aircraft. Some of the factors that the pilot's brain must consider almost automatically in building up his flying reflexes are:

(a) Size of the error—large error requires large corrective action.

(b) Past history of the error. (1) Is it building up rapidly?—if so, violent corrective action is required; (2) is it being corrected rapidly?—if so, the aircraft will overshoot unless the controls are reversed.

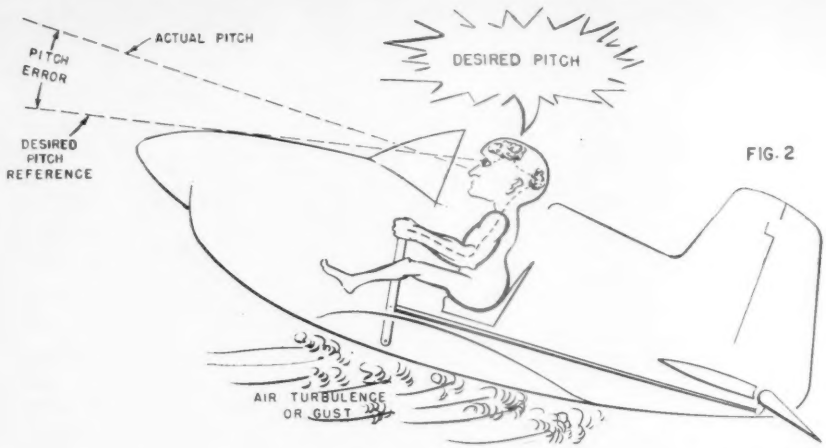


FIG. 2

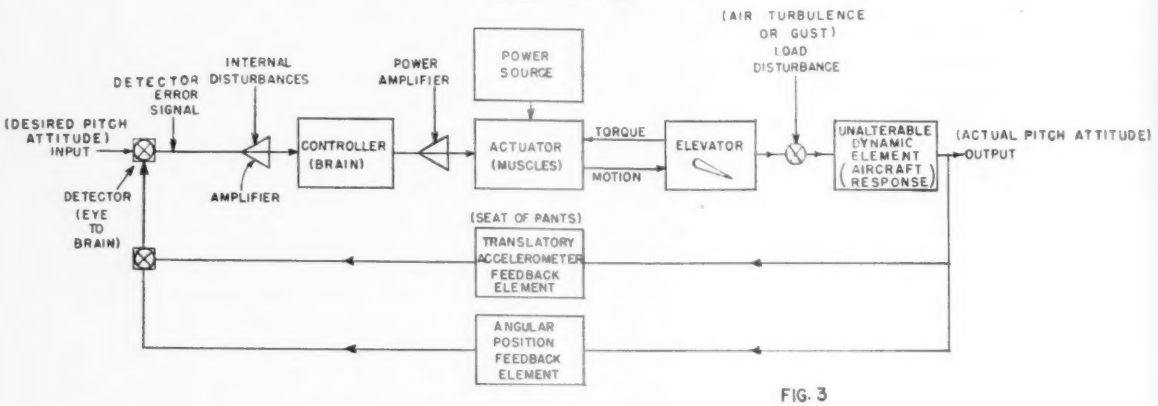


FIG. 3

(c) Response of the aircraft to a given amount of joystick pressure and motion at different altitudes and air speeds.

(d) Time required for this response to build up versus time required to move the surface.

(e) Effect of backlash and spring in the control links.

(f) Time required to recognize a true error from various types of illusions.

The mechanical counterpart of the pilot's brain is represented in the autopilot by the *amplifier* and *controller*. Evidently, the amplifier must ensure the detection of a satisfactorily small error, and the controller must have built into it the ability to anticipate the immediate future history of the error, evaluate the effect of this on the output, recognize the difference between a true error and extraneous signals arising from electrical and mechanical disturbances, and, with a knowledge of the aircraft's response to elevator motions (and the elevator's response to actuator signals), properly meter power to the *actuator*.

A signal from the controller must go to the Fig. 3 counterpart of the pilot's *muscles*. This is the elevator *actuator*, the source of mechanical power. Usually, the actuators for autopilots are hydraulic with electrical controls. They could, however, be electrical motors, pneumatic cylinders, or electrically operated clutches.

A block labeled "*unalterable dynamic element*" is inserted between the *elevator block* and the output line, because the direct result of the elevator motion is the generation of aerodynamic forces and moments. These combine with, and produce, other aerodynamic forces to cause angular and translatory acceleration of the aircraft corresponding to its pitch moment of inertia and mass but not alterable as far as autopilot design is concerned. Furthermore, there is added into the force line entering this block another input, representing the gust distributing forces (which we consider here will contribute an arbitrary component to the angle of attack) so that the aerodynamic response results from a composite of control and disturbing forces.

We complete the comparison by considering the analogue of the old pilot's phrase "flying by the seat of one's pants." The pilot's posterior padding is useful as an accelerometer. If properly sensitive it can tip him off to air disturbances and resultant accelerations before these become observable as angular errors. This is typical of a class of elements that measure dynamical responses of the output alone.

Other similar devices that we may use in an autopilot are rate gyros to measure aircraft angular velocity and integrating or differentiating elements to measure averages and rates of angular velocities. The block

diagram of Fig. 3 shows such elements as a block in the feedback loop between the output and detector.

(4) *The Control Loop.*—It will be seen that our block diagram has now doubled back on itself, forming a closed *control loop*. Such a closed loop is inevitable whenever the power is controlled by a difference (error) between the input and a function of the output. This loop defines the autopilot as a servo and a *closed cycle system* in contrast to an *open cycle system*, wherein the output is controlled without comparison of the input with a desired function of the output.

The control loop is characteristic of all servos. It has the effect of *forcing* a *desired function* of the output to equal the input within a tolerance defined by the detector error signal. This concept is basic to the understanding of all servos. Thus, no matter what the characteristics of the actuator and unalterable elements may be, sufficient dynamic amplification and anticipation can force them, within their performance limits, to produce almost the correct output, since any change in the output not corresponding to a change in the input will alter the error and, with sufficient amplification and anticipation a very small error can produce positive or negative peak operating power. This idea of feedback is often used on elements within the main control loop. Here its primary purpose is to force a correspondence between a desired function of the output of an element and the input. Such loops within loops are employed in amplifiers and actuators. Although not specifically shown in Fig. 3, most autopilot actuators employ a local feedback of control surface position around the hydraulic piston and valve to the electrical amplifier controlling the valve motion. This has the effect of rapidly compensating for aerodynamic hinge moment variations and actuator nonlinearities so that the control surface *motion* is nearly proportional to the valve input voltage. If it were desired to cause the control surface *velocity* to be proportional to the valve input voltage, the first derivative of the actuator motion, as obtained by a tachometer generator or an electronic differentiation of actuator position, would be fed back to the valve control input. If control surface *acceleration* were to be controlled, an accelerometer on the actuator output would feed back its signal, whereas if the *actuator force* must be proportional to the input, the hydraulic piston pressure drop or the strain in a driving link would be measured, amplified, and fed back into the valve input.

(B) *Static Error and Loop Gain*

The *amplifier* amplification and the resolution of the *detector* determine the system *static error*. This static error is interpretable as the smallest change in input which will produce a change in output.

Associated with static error is the idea of "*static* or *d.-c. loop gain.*" The static loop gain may be defined as the *ratio of the input to the detector on the feedback side to the detector error signal which produces it*—with no dynamic feedback element, this is, for the autopilot the ratio of the change in pitch angular velocity to the static pitch error which produces it. *Dynamic loop gain* is expressed in terms of system response to a sinusoidal detector error of unit amplitude. It is the amplitude of the sinusoidal input to the detector on the feedback side caused by a unit amplitude of sinusoidal detector error signal and is a function of the frequency of such an oscillation.

(C) *Stability*

(1) *Qualitative Description of Stability.*—One of the primary requirements of any automatic control device is that it be stable. Instability for the autopilot means that the aircraft either oscillates objectionably or refuses to remain in a desired attitude (such as occurs in a stall or spin). In either case it cannot be controlled. The oscillatory type of stability associated with "overshoot" has been mentioned briefly in the preceding section. It is not difficult to imagine on a qualitative basis. Thus, suppose that the aircraft runs into a gust that causes it to pitch. This action must be detected by the gyro pick-off and a signal generated to produce actuator motion. The actuator motion then applies a corrective *torque* to the aircraft, which changes its angular velocity. This in turn produces a corrective *motion*. Ideally, the process should end there. However, this chain of events takes *time*. Furthermore, the necessity for controlling the aircraft by a *torque* means that pitching velocity depends upon the *past history* and *not the instantaneous* value of all torques acting on the aircraft. By the same token, the angular position depends upon the *past history* of the angular velocity. Evidently, the aircraft will overshoot unless position and velocity can be brought to zero *simultaneously*. This is possible only by a proper combination of torque magnitude and time. If the reversal is too *small* or comes *too late*, an overshoot will result and the whole process will be repeated in reverse, causing an oscillation. If the original torque generated in response to the disturbances is too large (corresponding to a high loop gain) and the reversal comes too late, overshooting continues, causing *hunting*, or builds up, causing genuine *instability*. This indicates that an improper combination of the *time delay* and *loop gain* will produce unacceptable operation. Consequently, a good servo must have built into it means for *anticipating* the future history of the error and output motion in order to start corrective torques into action *soon enough* to prevent instability or hunting.

The above explanation makes no pretense at rigor. The proper adjustment of time delay and loop gain constitutes the major problems of controller design. These are complicated by the fact that both time delay and loop gain *vary* with error (and output) velocity, acceleration, higher order rates of change,* and altitude. Thus, we know from physical considerations that a high-frequency sinusoidal oscillation of the control surfaces does not produce so large a magnitude of aircraft

* Corresponding information is implied in saying that the time delay and gain vary with the sinusoidal frequency of the input.

angular motion as a lower frequency oscillation. This is an example of loop gain variation with frequency.

(*2*) *Summary of Effects of Loop Gain and Time Delay on Stability.*—In general, it is possible to predict that: (a) high loop gain means low errors in angular position unless instability results; (b) high loop gain and anticipation mean amplification of spurious effects such as backlash, spring, friction, and stray electrical signals; (c) a continued increase of loop gain leads to instability under all conditions; (d) for some systems, a loop gain lower than a certain amount also leads to instability (such systems are said to be *conditionally stable*); (e) time delay in signal propagation around the loop is a destabilizing factor.

(*3*) *A Definition of Stability.*—There are several definitions of stability, most of which are mathematical and and usable only for mathematically linear systems or special types of nonlinear systems. However, a definition that ensures the proper operation of an automatic control device requires that "a *temporary* change in the input produce a temporary change in that function of the output over which control is desired."

(*D*) *Summary of Elements in a Typical Servo*

(*1*) *Standard Elements.*—The elements necessary to control the aircraft have their counterpart in other types of servosystems. These elements may be summarized as:

(a) A single *input* that may be considered as the independent variable of the system.

(b) A single *output* that may be considered the dependent variable of the system and which represents the quantity being controlled.

(c) A device for detecting the difference between the input and output signal. This device has no universal name but may variously be a mechanical differential; a potentiometer; photoelectric, electromagnetic, or electrostatic pickup; and an input junction to an electron tube amplifier. It has previously been called an *error detector*.

(d) An error signal *amplifier*.

(e) A device for converting the amplified error signal into a form suitable for controlling the actuator. Such a device may change the energy and functional form of the error signal in order to produce better operation of the actuator. It may integrate and/or differentiate the error signal and perform other functional operations on it. This element of the system is a *controller*. It is often called an "equalizer," representing the debt which present-day servo theory owes to the field of communication engineering.

(f) A source of mechanical power and its power supply. This may be a d.c. motor, an a.c. motor, a hydraulic motor or piston, an air motor, and a constant speed motor and clutch. This source of mechanical power is called an *actuator*.

(g) *Unalterable dynamic elements.* These may consist of load inertia, load forces or moments which vary with output motion (such as hinge moments on an aircraft control surface) and load forces or moments which are independent of output motion (such as the aircraft's dynamic response).

(h) A device for converting the output motion into a desired function of output motion and an energy form suitable for comparison with the input. For example, it is sometimes desired to produce an output speed proportional to an input voltage.* The device in question might now be a generator on the output shaft which produces a voltage proportional to the output speed or, as in the autopilot, a rate gyro. Such a device is variously called a "*feedback element*," "*feedback transducer*," "*parallel controller*," or "*parallel equalizer*."

(*2*) *Disturbances in Servos.*—The foregoing elements are all that usually find their way into servo block diagrams. However, no block diagram or servo analysis has any claim to realism if it ignores four disturbances that ultimately determine much of the servo design and performance and which must, in fact, be considered as other inputs to the system. They may be listed as:

(a) Input uncertainties. These represent departures of the input signal arriving at the servo from the correct value of the input. They are particularly important wherever radio or optical position measuring apparatus are used to generate the input signal or wherever the input signal originates in another dynamical element.

(b) Output or load disturbances. These arise from friction "stiction" (breakaway friction); the binding of gears, bearings, and couplings; gear or link manufacturing errors; inertia in the presence of backlash, and spring.

(c) Internal errors. These may consist of nonlinearities in amplifying, detecting, or energy converting (transducing) elements; amplifier drift, variation of characteristics of elements with time, temperature, or pressure; mechanical backlash; mechanical friction; windage; thermal electronic agitation in metals; electronic tube background "noise"; unwanted electrostatic or magnetic coupling, mechanical deflection of shafts, bearings, brackets, couplings, or linkages and elasticity of hydraulic fluids, lines, and control elements.

(d) External disturbances. Included here are the effects of acceleration; mechanical vibration; acoustic vibrations; stray electrical or magnetic fields; and, in the autopilot problem, air turbulence.

These sources of error are often omitted in the block diagrams and theoretical treatment of servomechanisms because no all-inclusive and consistent theory has yet been developed to handle them. Nevertheless, the optimum minimization of such errors often takes 90 per cent of the servo engineer's time and ingenuity, representing the difference between the practical and idealized servo problems.

(III) Theoretical Design Methods

(A) *Introduction*

In designing an autopilot we encounter problems typical of other servos. The major effort is originally one of *synthesis*. Starting with an unalterable dynamical aircraft response, in anticipation of specified external disturbances, it is required to design the most reliable, cheapest, smallest, and lightest system that will fit into specified volumes in the aircraft and fly it with prescribed comfort and accuracy over a predetermined range of altitude, speed, and load variations. From the servo standpoint the variable elements here are the actuator, controller, and amplifier.

In synthesis, a whole repertory of possible designs must be considered and the emphasis placed on streamlined operations that attempt to pack approximate information about a great number of characteristics into single calculations. This results in a choice of specific dynamical characteristics which may then be investigated more exactly by methods of *analysis*.

The presently popular tools of servo analysis and synthesis were first exploited by the electrical engineer in his design of communications networks and feedback amplifiers. It is not surprising therefore, that much of servo lingo is colored by electrical terminology (such as *gain, attenuation, phase, transient response, equalizer, frequency response, decibels* (d.b.), *octaves, power spectrum, noise, Nyquist criterion, Bode diagram*) and that most servo courses are taught in the electrical departments of engineering schools. This is traceable to the fact that the soluble mathematical formulation of servo system problems invariably leads to *linear* differential or integral equations that are identical in form with those of communications circuits.

The principal analytical tools consist of:

(a) Classical theory of linear differential equations with constant coefficients.

(b) Operational mathematics (Laplace and Fourier Transforms).

(c) Functions of a complex variable (principally complex algebra).

(d) Plots of output magnitude and phase for sinusoidal error of unit amplitude and zero phase. (1) Polar plots of output amplitude as radius versus phase as an angle (Nyquist diagrams); (2) log of amplitude and phase vs. log of error frequency.

(e) Nyquist's stability criterion.

(f) Bode's minimum phase network attenuation phase theorems.

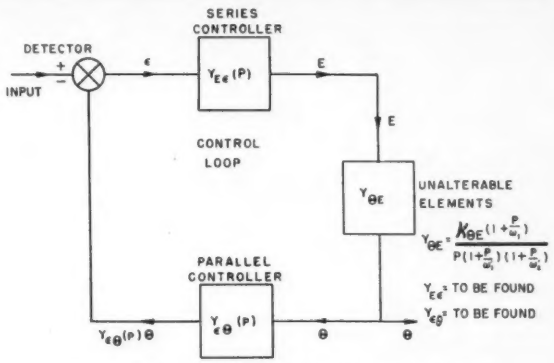
(B) *Outline af Steps in Autopilot Synthesis*

The following is a list of steps to be followed in a pitch autopilot design:

(1) Define desired performance in terms of allowable pitch errors under various conditions.

(2) Define input (desired pitch performance) dynamical characteristics.

(3) Define dynamical characteristics of disturbances.



SIMPLIFIED BLOCK DIAGRAM OF BASIC SERVO SYSTEM
FIGURE 4

(4) Define unalterable dynamical response of aircraft.

(5) Approximate (4) by linear differential equation with constant coefficients.

(6) Determine actuator torque-load characteristics in terms of elevator inertia, friction, backlash, spring, and aerodynamic hinge moment.

(7) Determine control surface motion required to give desired performance under limiting conditions of disturbance and input.

(8) From (6) and (7) determine limiting characteristics of actuator and select actuator. If power, speed, or acceleration requirements are unattainable, select best actuator available and calculate autopilot performance possible with it. This may mean a relaxation of the requirements of item (1).

(9) Approximate dynamical characteristics of actuator by an idealized device whose performance equations are linear with constant coefficients.

(10) Using (5) and (9), design the simplest controller which will approximately satisfy (1) in the presence of (2) and (3). Make sure it is physically realizable.

(11) Determine the need, if any, for parallel controllers.

(12) Analyze the selected system accurately to determine more exactly its idealized performance and make any changes that this analysis may show to be desirable.

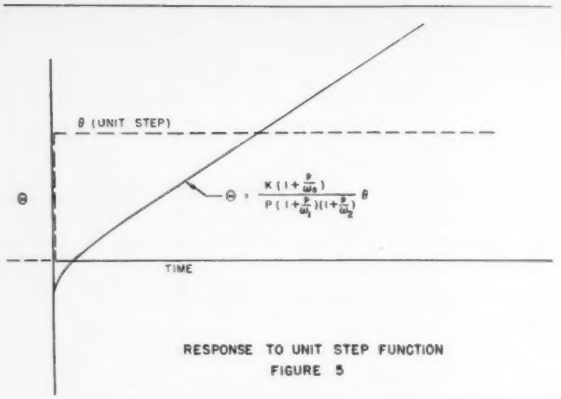
(13) Build model system supplying unalterable dynamical response and actuator loads as accurately as possible by an electrical or mechanical model (simulator) of the dynamical equations. Test and adjust until performance is satisfactory.

(14) Mount autopilot in aircraft and "debug."

(15) Repackage for better manufacturability, size, and weight. Items (13), (14), and (15) will normally require from 80 to 95 per cent of the total development time.

(C) *Servo Loop Relations*

The classical servo loop is shown in Fig. 4. Here θ is the input and Θ is the output. The effect of load dis-



RESPONSE TO UNIT STEP FUNCTION
FIGURE 5

turbances are (possibly wrongly) completely neglected. The quantities $Y(p)$ are linear operators defining the differential equation relating the input to the output. Thus,

$$p = d/dt \tag{1}$$

and

$$Y(p) = \sum_{i=0}^{i=n} A_i p^i / \sum_{i=r}^{i=m} B_i p^i = N(p)/D(p) \tag{2}$$

This means that, for example,

$$\Theta = Y_{\Theta E}(p)E \tag{3}$$

or, the equivalent differential equation

$$D_{\Theta E}(p)\Theta = N_{\Theta E}(p)E \tag{4}$$

Here $Y(p)$ is called the *transfer function* of the element whose input and output it relates.

It follows by elimination of $E[= Y_{E\epsilon}(p)\epsilon]$ that

$$\Theta = Y_{\Theta E}(p)Y_{E\epsilon}(p)\epsilon = Y_{\Theta\epsilon}(p)\epsilon \tag{5}$$

Therefore, transfer functions combine upon substitution as though they were algebraic coefficients.

The "typical" block diagram has broken the problem up into "alterable" and unalterable elements. The two controllers may be considered alterable elements, and the actuator-load-dynamic characteristics are unalterable (once the actuator has been selected). The servo theoretical synthesis consists largely of selecting the controller transfer functions that will give satisfactory performance.

The transfer function relations between output and input, output and error, and input and error may now be written as:

$$\Theta = [Y_{\Theta\epsilon}/(1 + Y_{\Theta\epsilon}Y_{\epsilon\Theta})]\theta = Y_{\Theta\theta}(p)\theta \tag{6}$$

$$\Theta = Y_{\Theta\epsilon}\epsilon \tag{7}$$

$$\epsilon = \theta/(1 + Y_{\Theta\epsilon}Y_{\epsilon\Theta}) \tag{8}$$

(D) Classical Methods of Synthesis

(1) *Transient Analysis.*—Two types of inputs are the basis for modern methods of servo synthesis. The first of these is a "unit step" input or, its first time derivative, the "unit impulse." The unit step is typified by the voltage pulse following the closing of a switch. It is zero up to a predetermined "zero" time and then rises instantly to a value of unity and continues at this value from then on. The unit step is useful because, from it, the response of a linear system to any input function may be constructed by the Duhamel integral. Fig. 5 shows a unit step and the response of a system characterized by the operator.

$$Y(p) = \frac{[1 + (p/\omega_0)]}{p[1 + (p/\omega_1')][1 + (p/\omega_2')]} \tag{9}$$

to such an input.

The unit step is experimentally convenient and would be analytically efficient as a tool of synthesis if it did not require the calculation of the roots, R_i, of the operational expressions $N(p)$ and $D(p)$. In the case where $N(p)$ is p, the response to a unit step in θ is called the *transient response* and takes the form

$$\Theta = \frac{p\theta}{D(p)} = \frac{p\theta}{(p - R_1)(p - R_2)\ldots(p - R_n)} = \sum C_i e^{R_i t} \tag{10}$$

Here the C_i are constants, the R_i are roots of $D(p)$ [values of p for which $D(p) = 0$], and the terms $e^{R_i t}$ are called the *normal modes.*

The difficulty of calculating R_i for any literal $D(p)$ containing more than two time derivatives makes the unit step analysis or *transient analysis* less suited to operations of synthesis than the so-called *steady state* or *frequency response* analysis to be discussed in the next section.

(2) *Steady-State Analysis.*—The most useful tool of modern servo synthesis is the response of the system to a sinusoidal input of unit amplitude and specified "circular frequency," ω. This is because:

(a) For such an input, the output is also a sinusoid of the *same* frequency, but amplitude A and phase Φ different from the input.

(b) The amplitude and phase are easily calculable by replacing the operator, p, by $j\omega$ (where $j = \sqrt{-1}$).

(c) The response of the system to a large variety of functions may be expressed as a Fourier series or Fourier integral whose time varying element at a given frequency is the sinusoidal response of the system for that frequency.

(d) System stability may be determined from the $\epsilon(j\omega)/\theta(j\omega)$ $\{= 1/[1 + Y_{\Theta\epsilon}(j\omega)Y_{\epsilon\Theta}(j\omega)]\}$ by the Nyquist criterion.

(e) Approximate rules can be set up for transient performance in terms of the maximum value of $A_{\Theta\theta}(\omega)$.

(f) Not only can system performance for a given controller be determined rapidly by graphical means, but these same graphs indicate what must be done to improve performance.

The analysis that uses this Frequency Response is called "*steady state analysis*" following the lead of the alternating current engineer. Here if

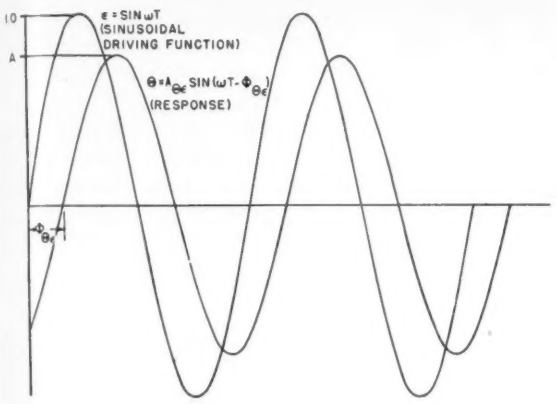


FIGURE 6
RESPONSE TO SINUSOIDAL DRIVING FUNCTION

$$\theta = \sin \omega t \tag{11}$$

$$\Theta = A \sin (\omega t + \Phi) \tag{12}$$

Fig. 6 is a plot of θ and Θ versus t for a typical controller.

(3) *The Nyquist Diagram and Nyquist's Stability Criterion.*—Fig. 7 is a polar plot of $A_{\Theta\epsilon}$ vs. $\Phi_{\Theta\epsilon}$ with $Y_{\epsilon\Theta}(p) \equiv 1$ for a typical aircraft pitch "unalterable dynamical response" and hydraulic actuator, represented by the Frequency Response.

$$Y_{\Theta\epsilon}(j\omega) = \frac{K_{\Theta\epsilon}[1 + (j\omega/\omega_0)]}{j\omega[1 + (j\omega/\omega_1')][1 + (j\omega/\omega_2')]} \tag{13}$$

This would represent the simplest controller (a straight amplifier), so it is examined for various characteristics that define aircraft performance. These are: (a) stability; (b) position error for a constant velocity input (*velocity error*); and (c) magnitude of signals above a certain frequency (most probably representing disturbances).

Stability is determined by *Nyquist's Criterion*, which is really a special case of a much older theorem of contour integration due to Cauchy. Strictly speaking, Nyquist's Criterion states that a system is stable if and only if a vector from the point $-1 + j0$ to the polar plot of $Y_{\Theta\epsilon}(p)Y_{\epsilon\Theta}(p)$ rotates around $-1 + j0$ in a *counterclockwise direction* a number of times exactly equal to the number of roots of $D_{\Theta\epsilon}(p)D_{\epsilon\Theta}(p)$, which have positive real parts as p takes the values:

$$p = \epsilon e^{j\Phi}, \qquad \epsilon \to 0 \quad \frac{-\pi}{2} \gtrless \Phi \gtrless \frac{\pi}{2}$$

$$p = j\omega, \qquad \epsilon \leqq \omega \leqq \infty$$

$$p = \infty e^{j\Phi}, \qquad \frac{\pi}{2} \leqq \Phi \leqq \frac{\pi}{2}$$

$$p = j\omega, \qquad -\infty \leqq \omega \leqq -\epsilon$$

Practically, if the polar plot of A vs. Φ for $Y_{\Theta\epsilon}(j\omega)$-$Y_{\epsilon\Theta}(j\omega)$ does not enclose $-1 + j0$ between it and the j axis, the system is usually stable. This means that, when $A_{\Theta\epsilon}A_{\epsilon\Theta}$ is unity, $-(\Phi_{\Theta\epsilon} + \Phi_{\epsilon\Theta})$ must be less than 180°. Practically, satisfactory transient performance is normally obtained only if Φ is from 150° to 130° or less when A is unity. This is a *phase margin* of 30° to 50°.

(4) *Standard Controllers.*—In Fig. 7, the system is never really unstable with $Y_{E\epsilon}(p)$ = (a constant) because Φ never becomes $-180°$. However, if its phase margin is 30° or greater, the velocity error will be too great, since this is proportional to $K_{\Theta E}K_{E\epsilon}$. Evidently, what is wanted is a curve that for low frequencies follows the dashed curve corresponding to a large value of $K_{\Theta E}K_{E\epsilon}$ and for high frequencies follows the solid curve, giving a satisfactory phase margin.

To do this we may:

(a) Use the high gain (large K) curve and put in a controller which attenuates more rapidly with increasing ω than its phase decreases in the region of unit dynamic loop gain. Such a device is called an *integral controller* and is shown in Fig. 8 as a resistance-condenser network.

(b) Use the high gain curve and put in a controller that advances the phase in the neighborhood of unit gain to give a satisfactory phase margin. Such a device is called a *lead controller* or *differential controller* and is shown in Fig. 9a as a network. It has the disadvantage of requiring large low-frequency amplification and magnifying high-frequency disturbances.

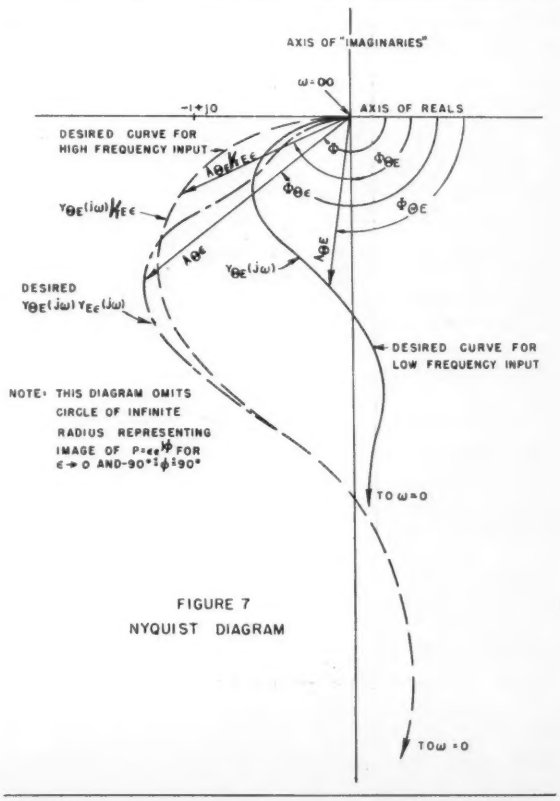
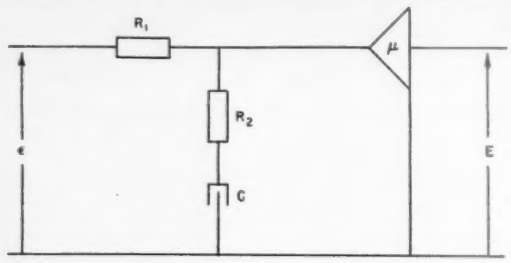
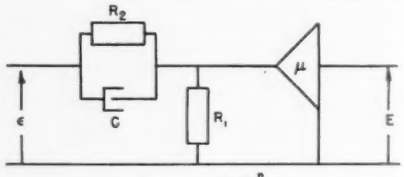


FIGURE 7
NYQUIST DIAGRAM



$$\frac{E}{\epsilon} = \frac{\mu\left(1+\frac{KP}{\Omega}\right)}{\left(1+\frac{P}{\Omega}\right)} \qquad \frac{1}{\Omega} = (R_1+R_2)C \qquad K = \frac{R_2}{R_1+R_2}$$

INTEGRAL CONTROL
FIGURE 8

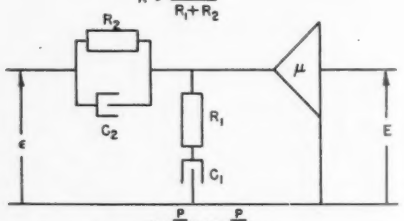


LEAD NETWORK CONTROLLER

$$\frac{E}{\epsilon} = \mu K \frac{\left(1+\frac{P}{\Omega}\right)}{\left(1+\frac{KP}{\Omega}\right)}$$

$$\Omega = \frac{1}{R_2C} \qquad (A)$$

$$K = \frac{R_1}{R_1+R_2}$$



$$\frac{E}{\epsilon} = \mu \frac{\left(1+\frac{P}{\Omega_1}\right)\left(1+\frac{P}{\Omega_2}\right)}{\left(1+K\frac{P}{\Omega_1}\right)\left(1+\frac{P}{K\Omega_2}\right)} \qquad (B)$$

$$\frac{1}{\Omega_1} = R_1C_1 \qquad \frac{1}{\Omega_2} = R_2C_2 \qquad \frac{1}{\Omega_3} = R_2C_1$$

$$K = \frac{1}{2}\left(1+\frac{\Omega_1}{\Omega_2}+\frac{\Omega_1}{\Omega_3}\right) + \sqrt{\frac{1}{4}\left(1-\frac{\Omega_1}{\Omega_2}+\frac{\Omega_1}{\Omega_3}\right)^2 + \frac{\Omega_1^2}{\Omega_2\Omega_3}}$$

INTEGRODIFFERENTIAL CONTROLLER

FIGURE 9

(c) Use the high gain curve and put in a controller that first attenuates and then advances the phase to give a satisfactory phase margin. Such a controller is called an *intergro-differential controller* and is shown in Fig. 9b as a network. It combines the good features of both integral and lead controllers.

(d) Go to a more complicated controller design.

(5) *The Logarithmic Diagram.*—A diagram that is faster to construct approximately plots log A vs. log ω and Φ vs. log ω. Here 20 log A is often used which gives the gain in *decibels* and log ω is expressed in *octaves* corresponding to successive doublings of the frequency. This is sometimes called a "Bode diagram" after H. W. Bode. Fig. 10 shows the Bode diagram corresponding to the Nyquist diagram of Fig. 7. Here the great virtue lies in the asymptotic construction, whereby the diagram for 20 log A can be roughed out rapidly by a series of straight lines and interpreted approximately in terms of servo stability, velocity error, and noise elimination. Furthermore, the controller dynamical characteristics can be obtained by simply subtracting the characteristic for 20 log $A_{\Theta E}$ from a desired characteristic, 20 log $A_{\Theta\epsilon}$. This is because $A_{\Theta\epsilon} = A_{\Theta E}A_{E\epsilon}$ so that

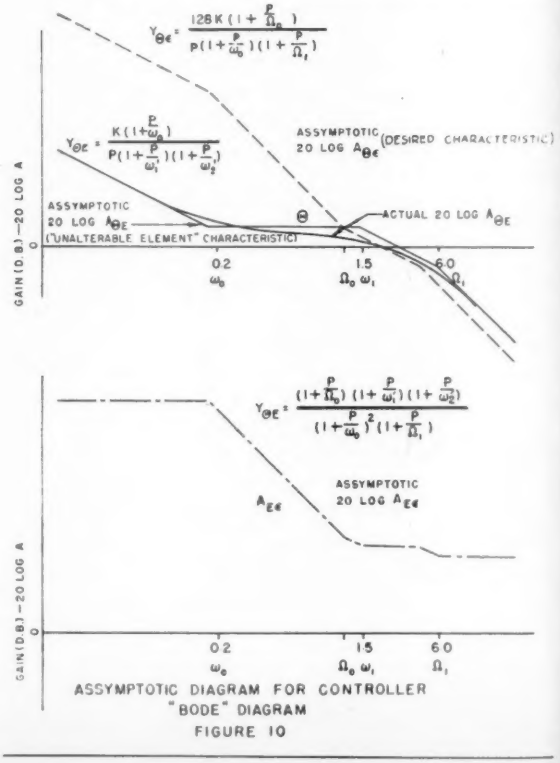
$$\underset{\text{controller}}{20 \log A_{E\epsilon}} = \underset{\text{desired}}{20 \log A_{\Theta\epsilon}} - \underset{\text{unalterable}}{20 \log A_{\Theta E}} \qquad (14)$$

The asymptotic diagram is constructed from a factored form for Y. This is, for a typical aircraft pitch angle-actuator input characteristic,

$$Y_{\Theta E}(j\omega) = \frac{K_{\Theta E}[1 + (j\omega/\omega_0)]}{j\omega[1 + (j\omega/\omega_1')][1 + (j\omega/\omega_2')]}$$

Each factor is approximated by unity if ω/ω_i is less than unity and $j\omega/\omega_i$ if ω/ω_i is greater than unity. The constants ω_0, ω_1', ω_2', etc., are called *break points* or *corner frequencies*. The actual magnitude of the factor in question at a single break point is $\sqrt{2}$, so that the actual curve goes approximately 3 db. away from the break on its concave side. Where breaks occur close together the approximations are less valid.

The Bode diagram permits estimation of the phase margin from the 20 log A vs. log ω curve by a "rule of thumb" developed from one of Bode's minimum phase network theorems.



ASSYMPTOTIC DIAGRAM FOR CONTROLLER "BODE" DIAGRAM

FIGURE 10

The rule states that in a "flat" portion of the true curve the phase angle increases by about 90° for each 6 db. per octave slope of the 20 log A vs. log ω curve. For a suitable phase margin the rule of thumb requires the asymptotic plot to cross the unit gain (20 log A = 0) line (this is called *gain crossover*) at a slope of -6 db. per octave (or greater) at least one octave from a corner for every -6 db. per octave of slope immediately beyond the corner.

In Fig. 10 the desired characteristic, 20 log $A_{\Theta\epsilon}$ is shown as a dashed line. This is a stable system whose low-frequency gain has been increased by a factor of 128 (to improve constant velocity and acceleration performance) and whose attenuation has been increased by a factor of two (to reduce high-frequency noise) beyond ω_2'. The controller characteristic 20 log $A_{E\epsilon}$ is shown as the dash-dot line and apparently has the formula:

$$Y_{E\epsilon}(p) = K_{E\epsilon}\frac{\left(1+\frac{p}{\Omega_1}\right)\left(1+\frac{p}{\omega_1'}\right)\left(1+\frac{p}{\omega_2'}\right)}{[1+(p/\omega_0)]^2[1+(p/\Omega')]} \qquad (15)$$

Here, $\omega_0 < \Omega_1 < \omega_1' < \Omega_1' < \omega_2'$.

It is seen that the system of Fig. 10 is "*conditionally stable*," since a *decrease* in gain, as well as an *increase* in gain, will put the gain crossover on a -12 db. per octave slope. Actually, the system is never completely unstable since it can reach a phase margin of zero only at $\omega = \infty$. However, its operation would be unsatisfactory under changes in gain. It would not, therefore, be adaptable without gain regulation to an autopilot where loop gain varies with altitude and air speed.

The Bode diagram is useful as a preliminary step. Actually, any design must come to the point where true phase angles at least at *gain crossover* must be computed. If the gain crossover frequency is ω_c, this is:

$$\Phi = \sum \tan^{-1}\omega_c/\omega_i - \sum \tan^{-1}\omega_c/\omega_i' \qquad (16)$$

The Bode diagram should never be used blindly, whereas, from a stability standpoint, the Nyquist Criterion is foolproof.

(IV) Limitations of the Usual Analytical Methods

(A) *Limitations of Linearization—Nonlinearities*

The analytical methods of the previous section are based on the replacement of actual systems by what it is hoped will be equivalent linear systems. This overriding condition is the great limitation of modern methods of synthesis. Any physical system is replete with nonlinearities. Some are adequately masked for all small and slow input variations by internal feedback loops. Others are a source of continued annoyance and often command most of the development charges of a servo project.

Principal types of nonlinearities may be listed as:

(*1*) *Electronic Tube Amplifier Characteristics.*—Amplifiers are of limited capacity and reach a point where a further increase in the input produces no change in the output. This is a phenomenon of *saturation*.

(*2*) *Actuators.*—Actuators and power supplies are of limited power capacity and saturate similarly to amplifiers. Furthermore, they often have basic nonlinearities of their own. This is particularly true of hydraulic and pneumatic actuators, grab clutches, and split field, series electric motors.

(*3*) *Backlash.*—Backlash limits sensitivity and the permissible loop gain. It often leads to oscillations that depend upon the loop gain, the various types of friction, the location of the backlash inside or outside the loops, the existence of mechanical resilience, and mechanical or viscous friction.

(*4*) *Friction.*—Friction constitutes a load on the system and limits its static sensitivity. It is beneficial in the presence of backlash. Breakaway friction, or "stiction," causes undesirable starting impulses. Its effect may be minimized by continually vibrating the friction element so that static friction never has a chance to come into effect.

(*5*) *On-Off Signals.*—On-off signals constitute a wide departure from linearity. The faster such signals occur, the more nearly can the system be made to approximate linear operation. Otherwise, special methods of analysis must be used which are often either cumbersome or inaccurate.

Major effects of nonlinearities are to cause variations of equivalent loop gain together with actual bias errors in the presence of disturbances.

Thus, if a sinusoidal disturbance enters a *linear system*, its effect is directly superposable on the true signal and may be averaged to zero by a proper equalizer placed *anywhere* in the loop. With a nonlinear system this is not so. Fig. 11 shows how a sinusoidal vibration in a saturable system produces an *equivalent bias error* and reduction in average gain. This is important in practical servo design because it indicates that, in order to be effective as a vibration eliminator, a filter must be placed *between* the vibration source and any nonlinear element. Furthermore, the equivalent loop gain

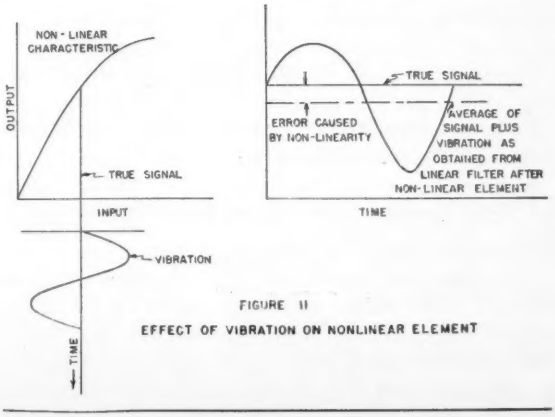


FIGURE 11
EFFECT OF VIBRATION ON NONLINEAR ELEMENT

evidently depends on the signal amplitude, and, with a concave characteristic curve, the equivalent loop gain is increased, whereas, with a convex curve, the gain decreases in the presence of a vibration. This often leads to temporary instability for certain signal magnitudes or undesirable sluggishness and steady-state errors for others.

(B) *Load Variations*

Every servo has at least two inputs. These are the energy twins, displacement and force, voltage and current, rotation and torque. The torque or current usually enters the system through the voltage or position output. They constitute the "load." The effect of load variations is often neglected in linear servo synthesis. The usual procedure is to attempt to mask the effect of such variations by feedbacks of actuator position, and/or integrals and rates thereof, around the actuator to the power amplifier input. This method is normally used in control surface actuator design to minimize the effect of actuator nonlinearities and aerodynamic hinge moments. It is not, however, always necessary or desirable to treat load variations in this way, particularly if they are discontinuous or rapidly varying. If the variations are wholly external, they can and should be treated as a second input to the system. If they depend nonlinearly on the output, they may usually be approximated by considering them as a second input, which is the same nonlinear function of the true input as they actually are of the output. For example, in the case of tight running gears, a variable torque load correlated with output motion is imposed on the output. This feeds back into the system and acts as a disturbance, which affects the output.

In cases where the load is a highly nonlinear function of the output, special simulators or computing machines must be employed, or the device must be built and modified experimentally.

(C) *"Noise"*

Disturbances or "noise" are an ever-present source of trouble in precision servos. The use of linear analysis and linear controllers restricts what can be done to minimize such spurious effects (except for special cases) without introducing objectionable distortions of the true signal.

(V) Future Trends

The future improvements in the servo art will probably take the following forms:

(A) *Development and Use of Computing Machines*

Machines applicable here will include:

(*1*) *Dynamical Analogues.*—Such analogues may be thought of as similar to present-day electronic differential analyzers and flight-characteristic simulators. They will be used to study in the laboratory tentative designs of servos that are too complicated to analyze mathematically and to select approximate design constants that give desired performance under simulated operating conditions of input and "noise." In addition, they will be used to simulate unalterable dynamical elements in test studies of prototypes of proposed servo designs.

(*2*) *Digital Computers.*—Design study problems requiring the investigation of a large combination of parameters in complicated, multiplicoupled systems will be greatly aided by general-purpose digital computers. Here, the major limitations are time, "memory" capacity, and coding capacity (whereas for an analogue device the number of analogue elements defines the problem that can be handled). This permits the digital computer to be used as a preliminary design tool in applications that may exceed the capacity of available analogue devices. Furthermore, the ability to code digital computers for repetitive operations greatly hastens the investigation of a large number of parameters.

(*3*) *Engineering Aid Computers.*—In this category falls a great miscellany of machines built up for handling special servo problems. Such machines include:

(a) Polynomial solvers for finding the roots of linear differential equations (such roots provide the normal modes and define the synchronizing performance of the device).

(b) Harmonic analyzers for decomposing a function of time into sinusoidal components.

(c) Harmonic synthesizers for generating the response of a system to a unit step or unit impulse from its response to unit sinusoids of varying frequency (frequency response).

(d) Nyquist diagram plotters to generate experimentally the Nyquist diagram of a system.

(e) Bode diagram plotters to generate experimental Bode diagrams.

(f) Correlation function computers to classify the statistical uncertainties in a system.

(g) Duhamel and Memory Function Integral machines to generate the response of linear systems to any inputs from their response to unit steps or unit impulses.

(h) Numerous additional special devices for handling techniques as yet undevised.

(B) *Development of Techniques for Synthesizing Multiplicoupled Systems*

In its present state, the servo art has concentrated on techniques for handling systems with one desired input and one desired output. There are, however, an increasing number of servo applications involving several inputs and outputs. A complete automatic pilot is such a device. Here, proper account must be taken of the interaction of roll, pitch, yaw, climb, sideslip, and pathwise motions. This requires, for precision control, a "mixer" to unscramble the roll, pitch, yaw, and thrust control "forces" and the six degrees of motion freedom, so that, for example, a control force in yaw will not produce an error in roll. Techniques

for the optimum design of such mixers are not presently developed to the same degree as techniques for "single" input-single output systems. The problem here requires a marriage of servos and computers. The autopilot is only one of many examples that might be cited. Another arises in the control of continuous flow chemical processes. Here, several components must be mixed in accurate proportion, and the problem has several inputs (the desired mixture ratios) and several outputs (the actual mixture ratios).

(C) *Development of Techniques for Minimizing Disturbances*

Perhaps the greatest single advance in the servo art will come in an improved way of minimizing the effect of unwanted uncertainties, disturbances, or "noise." This is the missing link of the precision servo field. A start on the problem has been made by various organizations, including major contributions from M.I.T. and the Bell Telephone Laboratories. Elsewhere, the usual procedure has been to assume that noise contains larger high-frequency components than true signal, so that the "approved" way of eliminating noise has been to build a filter that only passes low-frequency components of any signal without attenuation. This is unsatisfactory when the signals are large and rapidly varying such as occur during synchronizing operations.

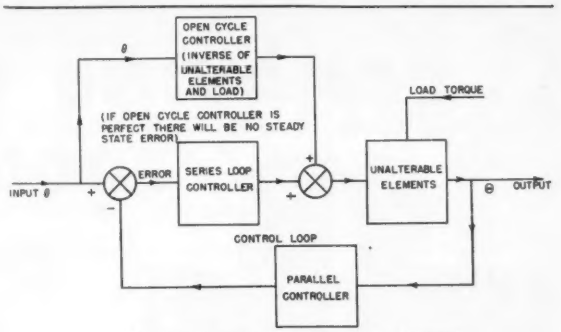
Even the most advanced present-day theory attempts to recognize the difference between signal and noise by their frequency characteristics alone. This permits the design of "linear" filters. However, to work only on the *relative* magnitude of various signal and noise frequency components is to leave untapped one of the most fruitful criteria of signal-noise separation available. This is the *absolute magnitude* of the signal and the noise or the absolute magnitude of derivatives of these quantities. A filter or computer capable of selecting signal and eliminating noise on the basis of absolute amplitude rather than the relative amplitudes is purposely nonlinear. The field of purposely nonlinear controllers is virgin and promises to present the greatest opportunity for improvement of precision servo performance.

(D) *Improvements in Linear Synthesis*

Improvements are continually being made in what has now come to be "orthodox" linear theory. Thus, it is possible to extend the Nyquist criterion to the synthesis of systems with predetermined minimum damping characteristics. There are also many others, ranging from new types of diagrams to special templates for drawing and interpreting already classical diagrams.

(E) *Combination Open Cycle-Closed Cycle System*

An open cycle system attempts to produce a desired output by operations on the input without benefit of comparison of the output and input. Examples of such are found in any type of meter where the output depends upon known properties of the instrument. This idea can be extended with profit to some servo applications. Here, operations on the input before the detector may be fed around the detector into the actuator amplifier, as shown in Fig. 12. In this way the actuator gets almost the correct signal even without generation of the error (the accuracy here depends upon the predictability of actuator, load, and unalterable element characteristics). Although the open cycle element does not affect the stability of the system, it makes possible the design of the feedback loop primarily from stability and noise elimination considerations without jeopardizing steady-state or synchronizing operations, since these are largely taken care of by the open cycle portion of the system.



COMBINATION OPEN CYCLE CLOSED CYCLE SYSTEM
FIGURE 12

This scheme will undoubtedly be exploited to the full in the future both for simple and multiplicoupled systems.

(F) *Digital Open Cycle Systems*

A major disadvantage of open-cycle systems is that without feedback they can accumulate error. However, with the development of digital computers that can reliably represent a number as a definite number of pulses, such accumulated errors are not possible. Notching motors, which act on the ratchet principle and advance a specified distance for each pulse, may now be operated from digital computers, which serve as controllers to produce superprecision automatic controls.

(VI) Conclusion

The preceding pages have attempted to explain on a physical basis the principles of operation of the aircraft industry's present and future mechanical servants. Improved methods of synthesis and achievement of the future trends outlined herein will combine with improved component design to make the application of servo systems to aircraft a most important contributor to the coming "age of flight."

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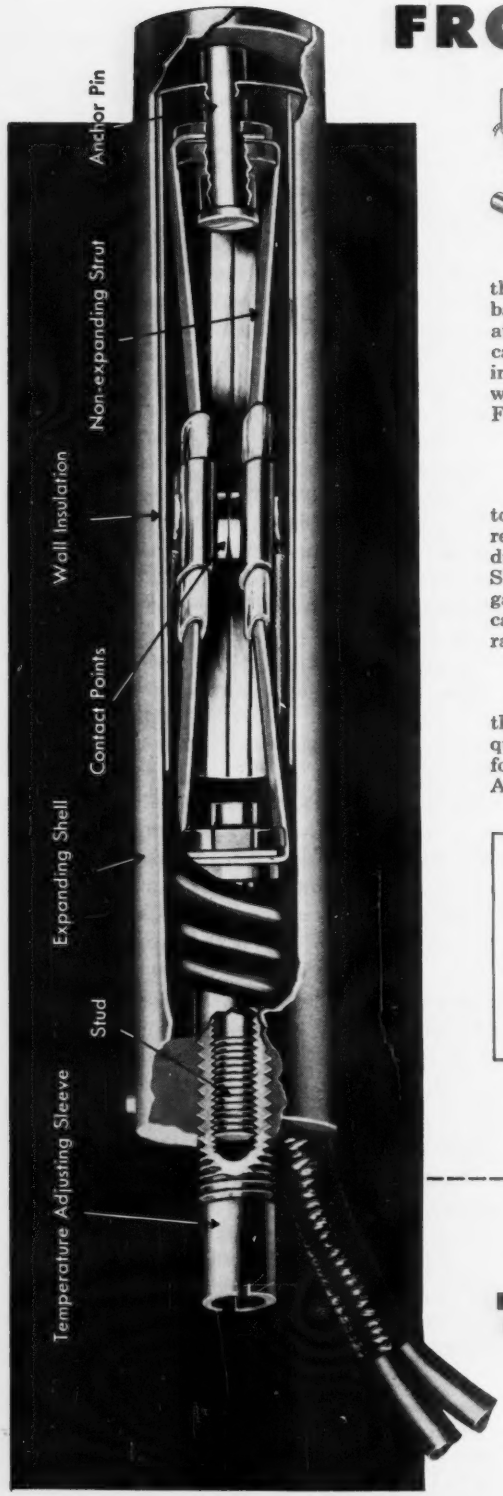
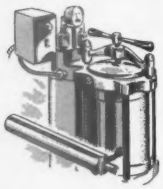
Hazen, H. L., *Theory of Servomechanisms*, Journal Franklin Institute, Vol. 218, No. 3, September, 1934.

(*Continued on page 71*)

REMOVING THE "Bugs" FROM A STERILIZER





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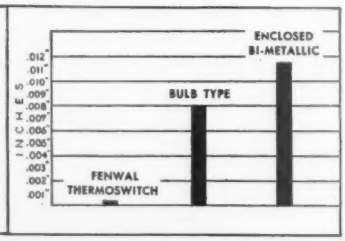

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I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

The Theory of the Impact Tube at Low Pressures

By

P. L. Chambré and S. A. Schaaf

University of California at Berkeley

A theoretical analysis has been made for an impact tube of the relation between free-stream Mach Number and the impact and free-stream pressures and densities for extremely low pressures. It is shown that the results differ appreciably from the corresponding continuum relations.

Airfoils in Slightly Supersonic Flow

By

Hsue-Shen Tsien and Judson R. Baron

Massachusetts Institute of Technology

An investigation is made to determine the performance of simple thin airfoils in the slightly supersonic flow region with the aid of the nonlinear transonic theory first developed by von Kármán. Expressions for the pressure coefficient across an oblique shock and a Prandtl-Meyer expansion are developed in terms of a transonic similarity parameter. Aerodynamic coefficients are calculated in similarity form for the flat plate and asymmetric wedge airfoils, and curves are plotted. Sample curves for a flat plate and a specific asymmetric wedge are plotted on the usual coordinate grid of C_l, C_d, and $C_{m_c/4}$ vs. angle of attack and C_l vs. Mach Number to illustrate the apparent features of nonlinear flow.

Efficient Applications of Stringer Panel and Multicell Wing Construction

By

George Gerard

New York University

Under the structural loading conditions of transonic Mach Number flight, stringer panel type of wing construction and multicell construction were examined to determine the conditions under which each indicated efficient structural applications.

From an analysis of structures of optimum design, stringer panel wings appear to have a wide range of efficient application. Only in the range of extremely high loadings and small thickness ratios does multicell construction indicate efficient applications.

It is to be noted that the results obtained are strongly influenced by practical considerations involved in the manufacture of such wings.

Please do not order Preprints of these papers at this time.

See the December issue for Preprints that are immediately available.

Methods for Predicting Phenomena in the High-Speed Flow of Gases

By

M. J. Lighthill

University of Manchester, England

This synopsis of compressible fluid dynamics was read in a shortened form before the Seventh International Congress of Applied Mechanics. It treats successively, with full references, the foundations of the subject, the boundary layer, isentropic flow, plane waves, and the differences between steady sub- and supersonic flow; the perturbation methods of solution, including the linearized theory of supersonic flow in its many ramifications, are described and compared with more exact work in certain cases, and the theory of characteristics is outlined. The memorandum ends with a full discussion of the uses of the hodograph transformation.

Bending and Buckling of Sandwich Beams

By

N. J. Hoff and S. E. Mautner

Polytechnic Institute of Brooklyn and Skydyne Inc.

Formulas are derived for the calculation of the deflections of sandwich beams and of the buckling load of sandwich columns. Beam and column tests carried out on 64 specimens are described. The agreement between theory and experiment was found to be good in the column tests when the core was balsawood and in all the beam tests. A number of sandwich columns having a cellular cellulose acetate core failed under loads smaller than those predicted by theory. The early buckling was probably caused by weak spots in the core material or the adhesive.

Keeps ice from choking a jet's throat

ICING conditions pose a brand-new problem for jet planes. If ice forms in the narrow air intake of a jet engine, it chokes off the vital air supply. Without air, there's no combustion. And the jet engine quits cold.

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Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

The abstracts are classified according to the Standard Aeronautical Indexing System. Numbers in parentheses indicate the position of the Division Headings in the numerical arrangement. Headings marked by an asterisk have not yet been established by the S.A.I.S.

Aerodynamics (2) 48
Aerodynamic Loads 48
Boundary Layer 48
Control Surfaces 49
Fluid Mechanics & Aerodynamic Theory 49
Internal Flow 50
Performance 51
Stability & Control 51
Thermo-Aerodynamics 51
Wings & Airfoils 52
Airplane Design & Description (10) . . . 55
Airports & Airways (39) 55
Atomic Energy (48) 55
Aviation Medicine (19) 55
Comfortization (23) 56
Electronics (3) 56
Engineering Practices & Aids (49) 56
Equipment
Electrical (16) 56
Hydraulic & Pneumatic (20) 56
Flight Safety & Rescue (15) 56
Flight Testing (13) 56
Fuels & Lubricants (12) 57
Gliders & Gliding (35) 57
Guided Missiles (1) 57
Instruments (9) 57
Laboratories, Aeronautical (50) 59
Machine Elements (14) 59
Maintenance (25) 59
Management & Finance (45) 59
Materials (8) 59
Metals & Alloys 59
Nonmetallic Materials 60
Sandwich Materials 60
Meteorology (30) 61
Military Aviation (24) 61
Navigation (29) 63
Operations
Commercial (41) 63
Ordnance & Armament (22) 63
Photography (26) 63
Power Plants 63
Jet & Turbine (5) 64
Reciprocating (6) 64
Rocket (4) 65
Production (36) 65
Propellers (11) 65
Reference Literature (47)
History 67
Rotating Wing Aircraft (34) 67
Sciences, General (33)
Physics 68
Stress Analysis & Structures (7) 68
Thermodynamics (18) 69
Water-Borne Aircraft (21) 69
Wind Tunnels (17) 71

II. BOOKS REVIEWED IN THIS ISSUE

Supercharging the Internal Combustion Engine. E. T. Vincent 73
Reviewed by Kenneth Campbell, Wright Aeronautical Corporation

Advances in Applied Mechanics. Edited by Richard von Mises and Theodore von Kármán 74
Reviewed by Dr. Stephen J. Zand, Lord Manufacturing Company

Heat Conduction. L. R. Ingersoll, O. J. Zobel, and A. C. Ingersoll 76
Reviewed by Prof. Joseph H. Keenan, Massachusetts Institute of Technology

Aircraft Basic Science. Chief Editor, Charles Edward Chapel 76
Reviewed by C. S. (Casey) Jones, Academy of Aeronautics, Inc.

Aircraft Power Plants. Chief Editor, Charles Edward Chapel 77
Reviewed by Charles C. Greene, Board of Education, City of New York

Book Notes **77**

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Aerodynamics (2)

The Entomopter. Alleander Jordanoglou. *American Helicopter*, Vol. 12, No. 11, October, 1948, pp. 6–8, 20, 21, illus., figs.

A machine was constructed which reproduced the winnowing motion of insect wings during flight. By this machine the lift and the angle of incidence of the wing at any point in its flight path could be measured. The measurements of lift forces did not agree with theoretical calculations according to the formulas developed by A. Mangan because the inertia of the model wings was unbalanced. The pulsating airflow caused by the wings may cause a considerable reduction in the drag of such a propulsive device and provide a source of thrust more efficient than the propeller.

AERODYNAMIC LOADS

Flight Determination of Wing and Tail Loads on a Fighter-Type Airplane by Means of Strain-Gage Measurements. William S. Aiken, Jr. *U.S., N.A.C.A., Technical Note No. 1729*, October, 1948. 23 pp., diagr., figs. 4 references.

The center of pressure of the wing additional air load remained constant near the lifting-line-theory value between flight Mach Numbers 0.2 and 0.8. The fuselage load per unit normal acceleration appeared to be unaffected by changes in the Mach Number. Adequate correlation was obtained between various tail-load parameters derived from flight-test results and from the results of wind-tunnel tests. Strain-gage measuring proved to be an accurate and convenient method for determining loads in flight.

Flight Measurements of Buffeting Tail Loads. Allen R. Stokke and William S. Aiken, Jr. *U.S., N.A.C.A., Technical Note No. 1719*, October, 1948. 19 pp., diagr., figs. 5 references.

Magnitudes and frequencies of buffeting tail loads were measured in flight on a fighter-type airplane up to Mach Numbers of about 0.80. The buffeting tail-load increment for a constant dynamic pressure decreased with increasing Mach Number. Critical combinations of buffeting and maneuvering tail loads that are above the limit load and approach the design load for the horizontal stabilizer may occur in low-altitude, low-speed flight, with rearward centers of gravity at the limit design acceleration.

The Effects of Compressibility on the Lift, Pressure, and Load Characteristics of a Tapered Wing of NACA 66-Series Airfoil Sections. Morton Cooper and Peter F. Korycinski. *U.S., N.A.C.A., Technical Note No. 1697*, October, 1948. 59 pp., illus., diagr., figs. 19 references.

Results of tests of a 12-ft.-span tapered wing of NACA 66-series sections at Mach Numbers up to 0.69 indicated that the maximum lift coefficient varied appreciably with Mach Number and was affected to a marked extent by the sharpness of the leading edge at the higher Mach Numbers. No significant changes in span load distribution occurred through the Mach Number range for all angles of attack below the stall. The formation of extensive local supersonic-flow regions caused the center of pressure to move forward at high angles of attack and high Mach Numbers.

An Analysis of the Airspeeds and Normal Accelerations of Sikorsky S-A 42Airplanes in Commercial Transport Operation. Walter G. Walker. *U.S., N.A.C.A., Technical Note No. 1733*, October, 1948. 13 pp., figs. 7 references.

The results of an analysis of V-G data taken on four Sikorsky S-42A flying boats operated on Caribbean routes and along the east coast of South America during the period from 1936 to 1939. Investigation was made of the influence of operating speeds and routes on the flight loads. A comparison of the summarized data for the S-142A and the flight-load results with analyses of Boeing S-307 airplanes operating in the same general region show good agreement with respect to route roughness and do not show greater route roughness than most of the other routes that have been examined.

BOUNDARY LAYER

Investigation of Boundary-Layer Reynolds Number for Transition on an NACA 65 (215)-114 Airfoil in the Langley Two-Dimensional Low-Turbulence Pressure Tunnel. Albert L. Braslow and Fioravante Visconti. *U.S., N.A.C.A., Technical Note No. 1704*, October, 1948. 22 pp., illus., figs. 7 references.

Although the value of the boundary-layer Reynolds Number at various positions of transition from laminar to turbulent flow was found to vary in magnitude from 6,700 to 8,000 at positions ranging from 25 to 50 per cent chord, the results indicated that, by

use of a fixed value of 8,000, estimates of the transition points and drag coefficients could be made within approximately 7 per cent chord and 0.0003, respectively, on a smooth and faired low-drag-type airfoil operating in the low-drag range.

CONTROL SURFACES

Correlation of Model and Full Scale Hinge Moments. I—Frise Ailerons on a Harvard II Aircraft. R. J. Templin and B. Etkin. *Canada, National Research Council, Aeronautical Report No. AR-4 (N.R.C. 1721, MA-167)*, 1948. 27 pp., illus., figs.

Test data obtained in a wind tunnel with a 0.40 scale model of the outer wing panel and full-scale measurements of the lift and hinge moments measured in flight on a Harvard II aircraft were reduced to the common case of an aircraft with an infinitely rigid wing, no tail, and no slipstream, to facilitate correlating the two sets of measurements. The most important single factor in the correlation was found to be the corrections required for restraint of the wind-tunnel walls because the model was large relative to the size of the tunnel. The full-scale and model results checked closely enough that the model data, when properly interpreted, could be used for quantitative design purposes, since, in most cases, the results agree within the range of variation that can be expected among nominally identical aircraft.

Portances Comparées de Différents Systèmes Hypersustentateurs (Comparative Lift of Various Systems of High-Lift Devices). L. Coroller and J. Illaire. *France, Groupement Français pour le Développement des Recherches Aéronautiques, Note Technique No. 3*, April, 1939. 27 pp., figs.

FLUID MECHANICS & AERODYNAMIC THEORY

Methods of Linearization in Compressible Flow. I—Janzen-Rayleigh Method. F. E. Ehlers. Under the supervision of G. F. Carrier. *U.S., Air Force, Technical Report No. F-TR-1180-ND (GDAM A-9-M IV/I)*, February, 1948. 101 pp., figs. 42 references.

A summary of the mathematical techniques that have been developed to determine the velocity field in the vicinity of an obstacle in steady compressible flow. In addition to the original Janzen-Rayleigh method, these include, for two-dimensional flow, Poggi's method of sources and sinks, Kaplan's method of residues, Sauer's numerical method for two-dimensional and axially symmetric flows, Imai's method of successive approximation by which the Kutta-Joukowski theorem is extended to compressible flows, and also Imai's method of residues for the velocity distribution on the contour of a cylinder by which both the first and the second approximation to the compressible flow is obtained. This last method is illustrated by the numerical calculation of the velocity distribution and the pressure distribution on a circular cylinder in an infinite compressible stream. More particular problems that have been investigated include the circular cylinder in a uniform channel and in a limited free stream; the velocity distribution and the pressure distribution on an elliptic cylinder and the moment about the origin of its coordinates; the nearly elliptic cylinder and the Rankine oval in uniform channel; the general Joukowski airfoil, its velocity distribution and moments; and the symmetrical Joukowski airfoil and the circular arc profile. The Janzen-Rayleigh method is applied to three-dimensional flow for the case of the sphere and ellipsoids of revolution. The relative merits of the various methods are briefly evaluated.

The Fundamental Differential Equations and the Boundary Conditions for High Speed Slip-Flow, and Their Application to Several Specific Problems. Richard Schamberg. *California Institute of Technology, Thesis (Ph.D.)*, May, 1947. 272 pp., figs. 40 references.

An analytical investigation of the behavior of rarefied gases in which the ratio of the free molecular path to the macroscopic dimension characteristic of the gas flow is greater than $1/100$ and less than unity. The complete second approximation to the molecular velocity distribution function is calculated for the molecular model of Maxwell and then used to derive the macroscopic differential equations of motion and the associated boundary conditions. Although the differential equations of motion for slip flows are of higher order than those of continuum gas dynamics, the same number of boundary conditions are required. Second approximations are obtained for the slip velocity and the temperature jump. In applying the general equations to specific problems, it is found that the rarefaction of a gas increases the damping of sound waves, whereas the propagation speed differs from ordinary adiabatic sound velocity by less than 2 per cent. The slippage of gas and the temperature discontinuity at a solid boundary may, in the high-speed Couette flow of a rarefied gas, reduce the gas-dynamic friction coefficient and heat transfer by 10 per cent, under approximate conditions. The theory presented is applicable to the flight of aircraft at high altitudes ranging from 100,000 to 500,000 ft.

Applications of the Theory of Free Molecule Flow to Aeronautics. Holt Ashley. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 164*, 1948. 87 pp., figs., tables. 12 references. $2.50.

A study of the properties of the atmosphere at altitudes greater than 150 km. The properties of the atmosphere are computed by the N.A.C.A. method from assumed temperature and compositions at altitudes from sea level to 220 km. The low densities characteristic of high altitudes prohibit gas being considered a continuous medium and require the concept of free molecular flow and the principles of the dynamic theory of gases to be used to predict its behavior. In studying flows over bodies in this free-molecule region a parameter is introduced, M_∞, the ratio of flight speed to the most probable speed of air molecules, which serves as a reference for comparison of free-molecule flows. The techniques that are developed for finding analytically and numerically the lift and drag coefficients of a body of arbitrary configuration encompass both limiting conditions for the reflection characteristics of the surface of the body, diffuse reflection, and specular reflection. The aerodynamic coefficients at various altitudes and values of M_∞ are plotted and tabulated for a symmetrical airfoil at zero angle of attack; a sphere; a flat plate; cones and double cones with various half-angles; wedge and double-wedge airfoils; and a right circular cylinder with its axis perpendicular to the flow. The temperature of one side of a plane surface is calculated at various angles of inclination to the free-molecular stream. When applied to slender supersonic missiles these calculations show the drag forces to be negligible except at extremely high speeds. Aircraft that sustain themselves aerodynamically are shown to be possible. Their realization, however, would require a 500 kg. airplane with 10,000 sq.m. wing area and the use of some type of surface finish that would provide almost total specular reflection.

The Theory and Practice of Two-Dimensional Supersonic Pressure Calculations. N. Edmonson, F. D. Murnaghan, and R. M. Snow. *The Johns Hopkins University, Applied Physics Laboratory, Bumblebee Report No. 26*, December, 1945. 17 pp., tables.

A discussion of the steady two-dimensional flow of a perfect fluid which shows that an arbitrary curve, intersecting each of the straight-line patching (characteristic) curves in an expansive supersonic flow only once, can be treated as if it were a characteristic curve. It is thereby possible to obtain directly formulas for calculating the pressure distribution over an airfoil and, hence, to compute the lift, drag, and moment. The Ackeret linear theory and the Busemann quadratic theory are explicitly shown to be approximations to this more general theory. A set of six tables facilitates the calculation of the flow conditions accompanying oblique shocks and makes it possible to determine the pressure on a sufficient number of points on the upper and lower surfaces of a two-dimensional airfoil to obtain the lift, drag, and moment forces by numerical integration.

Supersonic Flow Fields About Bodies of Revolution. C. Ferrari. *(L'Aerotecnica, Vol. 17, No. 6, 1937, pp. 507–518.) Brown University, Graduate Division of Applied Mathematics, Translation No. A9-T-29 (Advance Copy)*, 1948. 25 pp., figs. 11 references.

The linearized equation of the velocity potential according to von Kármán is used to determine the flow about a cone in supersonic flow and to calculate the moments of the fluid forces acting on a slender body of revolution in subsonic flow. A more rigorous and more general method, based on the theory of characteristics, is used to determine the supersonic velocity field for the case in which the angle of attack differs from zero. In order to take into account the large and rapid compression that occurs at the vertex of the nose of a missile, an extension of an idea of Busemann is used to find the "best nose" of a projectile. A system of zero wave resistance is obtained by using a tubular body surrounding an ogive, which, in a manner similar to a Laval nozzle, continuously varies the kinetic energy of the fluid and transforms it without loss into pressure energy and vice versa.

On the Canonical Form of Equations of Steady Motion of a Perfect Gas. Max M. Munk and Robert C. Prim. *Journal of*

Applied Physics, Vol. 19, No. 10, October, 1948, pp. 957, 958. 2 references.

Neither constant entropy nor constant flow energy is assumed throughout the flow but only along individual streamlines. The five equations involving five dependent variables for the general steady motion of a perfect gas are thus reduced to four equations involving four basic dependent variables. This reduction of the number of basic variables is not restricted to regions between shock waves but relates to the entire flow, including shock waves.

Surface-Pressure Gradient and Shock-Front Curvature at the Edge of a Plane Ogive with Attached Shock Front. M. M. Munk and R. C. Prim. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 691–695, figs.

A simple method for computing the exact surface-pressure gradient and shock-front curvature at the edge of a plane ogive that is sufficiently sharp to be characterized, at high Mach Numbers, by the presence of a curved shock front attached to its edge. A comparison of the exact edge-pressure gradient and that given by two approximate methods of computing the pressure distribution along an ogive shows that the "tangent wedge" approximation is better at low Mach Numbers and the "wedge Prandtl-Meyer" approximation is better at high Mach Numbers. The numerical results, presented graphically, cover all ogives with attached shock fronts for Mach Numbers up to 13.

Variational Method in the Theory of Compressible Fluid. Chi-Teh Wang. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 675–685, figs. 13 references.

A formulation of the nonlinear problem of compressible flow passing an arbitrary airfoil. The velocity potential is set up by conformal transformation to satisfy the boundary conditions in the general case, thus making the Rayleigh-Ritz method applicable. A material saving in computational labor is obtained by using the Theory of Residues in the integration and a modified Crout method in solving the resulting simultaneous equations. Since the variational principle is valid for subsonic, sonic, and supersonic flows, it is apparently applicable to mixed-flow problems. The numerical results obtained for the calculation of the compressible flow around a circular cylinder compare favorably with those found by existing methods.

Vorticity in the Supersonic Flow About Yawing Cones. Mark M. Lotkin. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 656–660, figs. 4 references.

A comparison between Stone's and Sauer's methods of calculation of the supersonic flow about a slightly yawing cone shows that the neglect of vorticity, while having only a small effect on the ratio of the shock yaw to cone yaw, may lead to erroneous values of the normal force coefficient.

Tables of Hypergeometric Functions for Use in Compressible-Flow Theory. Vera Huckel. *U.S., N.A.C.A., Technical Note No. 1716*, October, 1948. 13 pp., tables. 2 references.

A tabulation of various hypergeometric functions that arise as particular solutions of Chaplygin's differential equation. They should be found useful in the numerical evaluation of auxiliary functions that may arise in the solution of problems of compressible flow.

Application of a Model System to Illustrate Some Points of the Statistical Theory of Free Turbulence. J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 37.*) *K. Nederlandsche Akademie van Wetenschappen, Verhandelingen*, Vol. 43, No. 1, 1940, pp. 2–12, fig. 11 references. (In English.) (Reprint.)

Force- and Pressure-Distribution Measurements on Eight Fuselages. G. Lange. (*ZWB Forschungsbericht Nr. 1516*, October 1941.) *U.S., N.A.C.A., Technical Memorandum No. 1194*, October, 1948. 35 pp., figs., tables. 4 references.

Measurement of the pressure distribution and the forces acting on fuselages were made to determine the effect of variations in slenderness ratio, position of maximum thickness, and nose ratio on the force and moment coefficients. The linearity of the difference between the theoretical and experimental fuselage moments made it possible to indicate a neutral point and its travel with the variation of the different parameters. Pressure-distribution measurements gave absolute values for increase in velocity. Theoretical calculations agreed well with measurements at small angles of attack but differed considerably at greater angles of attack where potential flow could no longer be assumed.

Cavity Drag in Two and Three Dimensions. Milton S. Plesset and Philip A. Schaffer, Jr. *Journal of Applied Physics*, Vol. 19, No. 10, October, 1948, pp. 934–939, figs. 7 references.

The free streamline theory has been applied to the computation of the cavity drag of symmetrical wedges of arbitrary angle. The drag coefficients and cavity widths and lengths are tabulated for a range of both cavitation parameter and internal angle. The pressure distributions computed for two-dimensional wedges have been taken to be approximately correct for cones of revolution of the corresponding internal angles. Under this assumption, drag coefficients for right circular cones of arbitrary internal angle have been computed and are tabulated for a range of both cavitation parameter and internal angle.

On the Application of Statical Mechanics to the Theory of Turbulent Fluid Motion; A Hypothesis Which Can Serve as a Basis for a Statistical Treatment of Some Mathematical Model System. J. M. Burgers. (*Delft, Technische Hoogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededeeling No. 39.*) *Nederlandsche Akademie van Wetenschappen, Verhandelingen*, Vol. 43, Nos. 8, 9, 1940, pp. 936–945; 1153–1159. 16 references. (In English.) (Reprint.)

Beschouwingen over de Statistische Theorie der Turbulente Stroming (Observations on the Statistical Theory of Turbulent Flow). J. M. Burgers. *Nederlandsch Tijdschrift voor Natuurkunde*, Vol. 8, No. 1-2, January, 1941, pp. 5–18. 14 references. (In Dutch.) (Reprint.)

INTERNAL FLOW

Friction Coefficients in the Inlet Length of Smooth Round Tubes. Ascher H. Shapiro and R. Douglas Smith. *U.S., N.A.C.A., Technical Note No. 1785*, November, 1948. 44 pp., figs. 15 references.

An experimental study of the friction coefficient near the inlet of smooth, round tubes with bellmouth entrances, using both water and air at low Mach Numbers, at Reynolds Numbers ranging from 39,000 to 590,000 which correspond to turbulent flow in the region of a fully developed velocity profile. The results are reported in terms of the apparent friction coefficient, which is a direct measure of the pressure drop and includes the effects of both friction and the changes in momentum flux associated with changes in velocity profile. Near the inlet, a zone was indicated where the developing boundary layer was laminar, followed by a zone in which the boundary layer was turbulent. The transition occurred at a Reynolds Number of about 5×10^5, which compared well with the corresponding value for a flat plate. In the inlet region the apparent friction coefficient was sometimes greater and sometimes less than the Kármán-Nikuradse coefficient for fully developed turbulent flow depending on the Reynolds Number. About 50 tube diameters were required for the local friction coefficient and about 80 tube diameters were required for the integrated friction coefficient to come within 5 per cent of the Kármán-Nikuradse value. Inducing turbulence artificially acted either to move forward the point of transition to turbulence or to eliminate the boundary layer altogether. The measured values of the apparent coefficient of friction in the laminar inlet zone support the laminar inlet theory of Langhaar. The integrated friction coefficients were in good agreement with those predicted by the laminar inlet theories of Langhaar, Schiller, and Atkinson and Goldstein, despite the wide divergences in predicted velocity profiles. The friction coefficient for developed flow was about 1.3 per cent higher than the Kármán-Nikuradse coefficient at the same Reynolds Number. A method, based on the experimental results, for estimating the discharge coefficient for rounded-entrance flow nozzles gave discharge coefficients in excellent agreement with published information on such nozzles.

Formation of Envelopes of Mach Waves on a Tangentially Struck Blade. W. Tollmien. (*Dresden, Technische Hochschule, Archiv Nr. 44/10*, May, 1943.) *Brown University, Graduate Division of Applied Mathematics, Translation No. A9-T-11* (*Advance Copy*), 1948. 29 pp., figs.

A mathematical analysis to establish a criterion to determine when the convergence of similarly running Mach waves leads to the formation of an envelope of Mach waves. The expression for the initial point of an envelope is obtained from an analysis of a family of straight-line left-running Mach waves. The equation of the right-running Mach wave, the equation of the streamline, curvature of the envelope, curvature of the shock front, and the relation between streamline curvature and shock-front curvature are obtained by considering the Mach waves that are formed when a blade inserted in a uniform undisturbed flow field is struck tangentially.

Unsteady One-Dimensional Flows with Heat Addition or Entropy Gradients. A. Kahane and Lester Lees. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 665–670, figs. 9 references.

Nonlinear differential Riemann types of equations are derived for the solution of problems involving the propagation of one-dimensional waves in flows in tubes of slowly varying cross section with heat additions or entropy variations. The equations can be solved graphically or numerically by the method of characteristics. The transient flows arising when heat is added to a section of an initially isentropic flow in a tube have been calculated. These calculations, in addition to affording an insight into the gas-dynamic aspects of intermittent heat additions in a flowing gas, show that at sonic velocity steady gas flows apparently behave anomalously, because, apparently, when a quantity of heat greater than the "critical" amount that would bring the gas to sonic velocity is added, compression waves are generated which travel in both directions and a new equilibrium flow is established.

The Theoretical Induced Deflection Angle in Cascades Having Wall Boundary Layers. George F. Hausmann. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 686–690, figs. 1 reference.

A theoretical analysis that employs a lifting-line theory and in which incompressible, nonviscous flow is assumed for the determination of the induced deflection angle in two-dimensional cascades having wall boundary layers. Two correction factors are derived for the deflection angle of the idealized infinite cascade. One accounts for the induced deflection due to the trailing vortex system in the wall boundary layer. The other accounts for the decrease in the total circulation of the bound vortex system. Plots show the effect of blade length, boundary-layer thickness, and the number of blades in cascade on the deflection angle of several typical cascade configurations.

A Graphical Determination of the Flow in Nozzles. Pierre Richard. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, pp. 293–296, 314, figs.

The method uses overlays and a system of logarithmic coordinates and allows problems concerning tuned and untuned nozzles to be solved. The position and amplitude of the shock wave can be determined without calculation. The method requires no interpolation.

PERFORMANCE

An Analysis of Range for Aircraft Project Design. A. H. Stafford. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, pp. 306, 307, figs.

A method for the estimation of still-air range when operating on constant power which uses a speed ratio based on the true speed for minimum drag at the selected cruising altitude at the instantaneous all-up weight of the aircraft. A rapid solution can be obtained once the basic aircraft characteristics and the design and operational parameters are known or have been evaluated.

STABILITY & CONTROL

A Theoretical Investigation of the Effect of Yawing Moment Due to Rolling on Lateral Oscillatory Stability. Joseph L. Johnson and Leonard Sternfield. *U.S., N.A.C.A., Technical Note No. 1723*, October, 1948. 20 pp., figs. 5 references.

The effect on lateral oscillatory stability of varying the value of the stability derivative (yawing-moment coefficient due to rolling-angular-velocity factor) over a wide range of negative and positive values has been determined theoretically for a sweptback fighter airplane with loading conditions simulating an airplane both with and without wing-tip fuel tanks. Increasing the stability derivative in a positive direction increased the damping of the short-period oscillation. For any given value of the derivative the addition of the wing-tip tanks, which involved shifting fuel from the fuselage to the wing tip, decreased the damping of the short-period oscillation.

A Simplified Method for the Determination and Analysis of the Neutral-Lateral-Oscillatory-Stability Boundary. Leonard Sternfield and Ordway B. Gates, Jr. *U.S., N.A.C.A., Technical Note No. 1727*, October, 1948. 45 pp., figs. 7 references.

The nature of the modes of motion as a function of the directional-stability derivative and the effective-dihedral derivative are shown to depend on the location of the stability boundaries plotted as a function of the same derivatives. For a large number of cases the last term of Routh's discriminant is negligible. Simplified expressions are developed on the basis of this assumption, which, when used as the necessary and sufficient conditions for a neutral-oscillatory-stability boundary, give results in good agreement with those obtained using the complete expression for Routh's discriminant. In addition, because of their simplicity, they allow the major parameters that affect the stability boundaries to be identified. Test functions are given which, if satisfied, indicate that the simplified expressions may be used.

Investigation of a $^1/_7$-Scale Powered Model of a Twin-Boom Airplane and a Comparison of its Stability, Control, and Performance with Those of a Similar All-Wing Airplane. Gerald W. Brewer and Ralph W. May, Jr. *U.S., N.A.C.A., Technical Note No. 1649*, October, 1948. 67 pp., illus., diagrs., figs. 5 references.

At the design center of gravity of 0.23 M.A.C. (mean aerodynamic chord), the twin-boom airplane had about 3 per cent static margin in the high-speed range with rated power and about a 5 per cent static margin at low speed with propellers windmilling and flap deflected to 40°. The all-wing airplane had a somewhat larger static margin than the twin-boom airplane for rated-power operation but much less static longitudinal stability at low speeds with propellers windmilling. In general, the twin-boom airplane had neutral stable trim elevator hinge-moment variations with air speed as compared with the more stable variations for the all-wing airplane. The twin-boom airplane will have about a 7 per cent shorter take-off run and will require about 9 per cent less distance to clear a 50-ft. obstacle than the all-wing airplane. Both aircraft have essentially the same performance in range and rate of climb.

Statische Dwarsstabiliteit, Dwarsbesturing en Stuurstandslijen in hun Onderling Verband; Beoordeeling en Meting Ervan door Middel van Vliegproeven (Static Lateral Stability, Lateral Control, and Control-Position Curves in Their Mutual Relation; Their Judgement and Measurement by Means of Flight Tests). H. J. van der Maas, A. J. Marx, and T. van Oosterom. *Netherlands, Nationaal Luchtvaartlaboratorium, Rapport No. V. 944 (Verslagenen Verhandelingen, Deel No. 9)*, 1940. 56 pp., diagrs., figs. 15 references.

Turret Tests on a Boeing B-17E and a Consolidated XB-32 (Five-Foot Wing Tunnel Test No. 393). E. L. Davis and D. W. Young. *U.S., Army Air Forces, Technical Report No. 5005*, September 1, 1943. 33 pp., illus., diagrs., figs.

Tests of $^1/_{16}$-Scale Model of General Motors XP-75 Fighter Airplane, Model No. 2 (Five-Foot Wind Tunnel Test No. 428). *U.S. Army Air Forces, Technical Report No. 5071*, January 18, 1944. 43 pp., illus., diagrs., figs.

THERMO-AERODYNAMICS

A Design Manual for Determining the Thermal Characteristics of High Speed Aircraft. I—A Summary of High Speed Convective Heat Transfer. H. A. Johnson and M. W. Rubesin. **II—The Flow Around Aerodynamic Shapes at Subsonic and Supersonic Velocities.** H. A. Johnson and F. M. Sauer. **III—Physical and Thermodynamic Properties of the Atmosphere up to an Altitude of 150 Miles.** H. A. Johnson and E. G. Slack. **IV—Radiation.** H. A Johnson and L. Possner. **V—Aircraft Heat Balances.** H. A. Johnson, E. G. Slack, and M. W. Rubesin. (*University of California, Department of Mechanical Engineering, Engineering Research Projects, Report.*) *U.S., Army Air Forces, Technical Report No. 5632 (ATI No. 13471)*, September 10, 1947. 171 pp., figs., charts. 84 references.

I. A general introduction to the fundamental concepts used in the analysis of the convective heat-transfer characteristics of bodies in high-speed fluid streams, in which is summarized the pertinent analytical and experimental work that has been done in the field. The heat-transmission and recovery factors are given for a flat plate, a wedge, and a cylinder at subsonic, high subsonic, and supersonic velocities. **II.** The local thermodynamic properties that prevail at the edge of the boundary layer near the surface of various aerodynamic shapes are determined from the pressure distribution in order to find the local convective heat-transfer rate to and from the surface. The method is illustrated for subsonic, transonic, and supersonic flows. **III.** In order to investigate the convective heat-transfer characteristics of aircraft flying velocities up to 6,000 m.p.h. and at altitudes as high as 150 miles, a reference atmosphere has been adopted based on the N.A.C.A. Standard Atmosphere from sea level to 65,000 ft., on the N.A.C.A. Tentative Standard Upper Atmosphere from 65,000 to 400,000 ft., and on current literature from 400,000 to 800,000 ft. The composition, temperature, and specific weight of the at-

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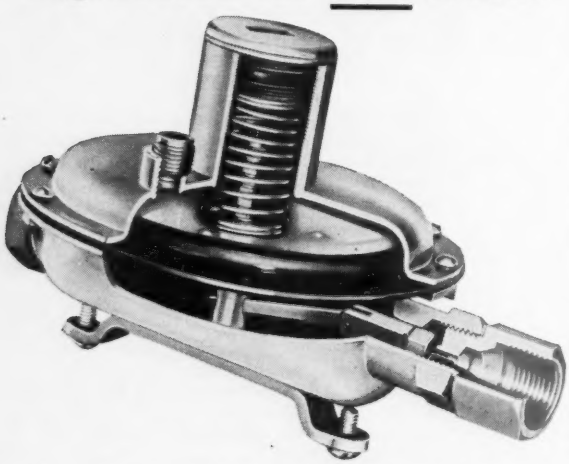

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mosphere are plotted as a function of altitude, and curves are given for the viscosity, thermal conductivity, specific heat, and Prendtl modulus for the temperature and pressure ranges existing at these altitudes. As an aid in estimating the validity of conventional heat transfer methods at extremely high altitudes, curves of mean molecular velocity, mean molecular free path, and the number of molecules striking a stationary square foot are presented as a function of altitude. **IV.** A simplified presentation of the basic principles of thermal radiation exchange insofar as it applies to an aircraft and its surroundings. The necessary atmospheric radiation data and the constants (emissivities) are given for the calculation of radiant energy balances. The radiant energy received from the sun, atmosphere, and earth are plotted as a function of altitude. **V.** In illustration of the material in the preceding sections, the skin temperatures of a cone, an airfoil, and the nose of a missile are determined from heat balances under various flight conditions for surfaces with various radiative characteristics. The calculations in this section and throughout the text are worked out in detail, and the methods are carefully explained in order to guide the designer in the necessary computations for high-altitude high-speed aircraft.

A Study of Skin Temperatures of Conical Bodies in Supersonic Flight. Wilber B. Huston, Calvin N. Warfield, and Anna Z. Stone. *U.S., N.A.C.A., Technical Note No. 1724*, October, 1948. 42 pp., figs. 14 references.

The agreement that is obtained between the time history of skin temperature measured on the nose of a V-2 missile and that calculated by Eber's experimental relation for heat-transfer coefficients for conical bodies under supersonic conditions appears to justify the use of Eber's relation in such calculations. This method is generalized and used to compute the variation of skin temperature with time for a wide range of values of the pertinent parameters. The results show that by proper selection of the basic parameters the increase of skin temperature during a limited time of flight can be held to structurally permissible values. Methods are given for taking into account the effects of solar heating and the radiation exchanged between the skin and atmosphere. Time histories of skin temperature are computed for three hypothetical supersonic flight plans.

Determination of Transient Skin Temperature of Conical Bodies During Short-Time, High-Speed Flight. Hsu Lo. *U.S., N.A.C.A., Technical Note No. 1725*, October, 1948. 42 pp., figs. 13 references.

A differential equation giving the fundamental relations between the transient skin temperature and the flight history provides a simple method for the determination of transient skin temperature of conical bodies during short-time, high-speed flight. The heat-transfer coefficient and the boundary-layer temperature are obtained from Eber's experimental results for conical bodies under supersonic conditions. The method is applied to flight at constant altitude to illustrate the effect of acceleration on transient skin temperature and then is applied to arbitrary flight. Several examples are given, for one of which measured data are available and are in good agreement with calculations.

WINGS & AIRFOILS

On Some Problems of Unsteady Supersonic Aerofoil Theory. A. Robinson. *College of Aeronautics, Cranfield, England, Report No. 16*, May, 1948. 22 pp., figs. 12 references.

The pressure of any given point on an airfoil of infinite span under forward acceleration at supersonic velocities can be analyzed into three components, one of which is the steady (Ackeret) pressure due to the instantaneous velocity. Of the other two, one depends directly on the acceleration and the other depends on the square of the velocity during a limited time interval preceding the instant under consideration. The difference, however, between the total-pressure and the steady-pressure components is such in all definitely supersonic conditions that are likely to be met in practice that it can be neglected. Pseudo-orthogonal coordinates are used to obtain a series of normal solutions for the velocity potential of oscillatory supersonic flow around a delta wing inside the Mach cone emanating from its apex and the corresponding normal incidence and pressure distribution.

Calculated Effects of Geometric Dihedral on the Low-Speed Rolling Derivatives of Swept Wings. M. J. Queijo and Byron M. Jaquet. *U.S., N.A.C.A., Technical Note No. 1732*, October, 1948. 21 pp., figs. 2 references.

Analysis indicates that the geometric dihedral has an appreciable effect on the lateral force due to rolling, that the damping in roll can be appreciably affected by geometric dihedral under some conditions, and that the yawing moment due to rolling is almost independent of geometric dihedral. The equations that have been derived by a simple theory, and the charts that have been compiled apply specifically to untapered wings; however, the relations that are presented are believed to be reliable for wings of taper ratio as low as 0.5. Some comparisons are made between calculated and experimental values of the rolling derivatives of an untapered 45° sweptback wing of aspect ratio 2.61 with geometric dihedral angles from −20° to 10°. In general, the agreement between experimental and calculated results over the low- and moderate-lift-coefficient ranges is good.

Comparison with Experiment of Several Methods of Predicting the Lift of Wings in Subsonic Compressible Flow. Harry E. Murray. *U.S., N.A.C.A., Technical Note No. 1739*, October, 1948. 33 pp., figs. 15 references.

An approximate adaptation of Kaplan's formula for the calculation of the effect of compressibility, which includes the thickness of a two-dimensinal airfoil, to swept finite-span wings. Comparison with experimental data shows better agreement than that obtained by the three-dimensional Prandtl transformation applied to the lifting-line theory or extended by Weissinger's approximate lifting-surface theory.

The Lift Increment of an Aerofoil Due to Variation of Incidence Along the Span, and a Simple Method of Estimating the Lift Distribution. M. Gdaliahu. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2261*, December, 1945. 12 pp., figs. 1 reference. British Information Services, New York. $0.90

A theorem is developed which solves, on the basis of the lifting line theory, the problem of the lift and spanwise lift distribution of a wing with a spanwise variation of incidence which arises when considering wings with flaps, linear twist, and ailerons or when calculating the rotary derivatives or the effect of downwash at the main plane caused by the foreplane of a tail-first aircraft. Simple formulas relate the lift increment and distribution produced by the spanwise variation in incidence to the lift distribution corresponding to constant unit incidence along the span.

Theoretical Method for Solution of Aerodynamic Forces on Thin Wings in Nonuniform Supersonic Stream with an Application to Tail Surfaces. Harold Mirels. *U.S., N.A.C.A., Technical Note No. 1736*, November, 1948. 25 pp., figs. 9 references.

The linearized solution for the aerodynamic forces acting on a thin wing in a nonuniform supersonic stream is presented as a three-component superposition. The effect of free-stream nonuniformity on the lift and moment forces depends only on the vertical perturbation velocity of the free stream at each point of the plan form. Expressions are given for the lift and moment solution for arbitrary plan forms and velocity distributions. The method is applied to determine the lift and moments acting on a rectangular tail surface due to a spanwise and linear parabolic upwash distribution.

The Transient Reaction of an Airfoil Due to Change in Angle of Attack at Supersonic Speed. Chieh-Chien Chang. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 635–655, figs. 14 references.

The superposition of Possio's solution of simple sources is used to find the force and moment acting on a thin airfoil in a supersonic stream of constant velocity when the angle of attack, after having been constant for a long period of time, increases linearly for a brief interval and then remains constant and when the angle of attack changes arbitrarily with time. When the change is linear with time, a Fourier integral is used for the downwash to evaluate the velocity potential, and the pressure, lift, and moment are expressed explicitly as a function of time. When the angle of attack is an arbitrary function of time, the pressure, lift, and moment are obtained approximately by superimposing a number of downwashes that increase linearly with time. If the second derivative of the angle of attack is a continuous function of time, the lift and moment can be expressed as a group of integrals. For an airfoil in a flow of constant supersonic speed, the transient reaction will damp out immediately after the change in angle of attack ceases. When this has taken place, the lift, wave drag, and moment become the same as given by Ackeret in the two-dimensional case. The transient reaction becomes more pronounced and lasts longer if the free-stream velocity approaches the velocity of sound or if the Mach Number approaches 1.

Transonic Separation. Vernon Outman and Arthur A. Lambert. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 671–674, figs. 1 reference.

Examination of flight-test data and wind-tunnel data show that the angle between the aft surface of a body and the line of flight may be taken as a preliminary design parameter by which the Mach Number may be determined at which airflow separation and buffeting will occur on aerodynamic bodies and lifting surfaces. For wing-body junctures and tail intersections the Mach Number at which separation takes place is approximately $0.10M$ greater than the critical Mach Number.

Investigation of the Variation of Maximum Lift for a Pitching Airplane Model and Comparison with Flight Results. Paul W. Harper and Roy E. Flanigan. *U.S., N.A.C.A., Technical Note No. 1734*, October, 1948. 18 pp., diagr., figs. 3 references.

Apparatus was developed which utilized a pitching airplane model to determine maximum wing loads as a function of the rate of change of angle of attack. In order to evaluate the pitching-model technique, the maximum lift coefficient was determined as a function of the rate of change of angle of attack, over a Mach Number range from approximately 0.2 to 0.6, in wind-tunnel tests of a $^1/_{10}$-scale model of a conventional single-engined fighter airplane and was compared with existing flight data of this airplane. The wind-tunnel and flight results were found to be in good agreement.

Charts for Determining the Characteristics of Sharp-Nose Airfoils in Two-Dimensional Flow at Supersonic Speeds. H. Reese Ivey, George W. Stickle, and Alberta Schuettler. *U.S., N.A.C.A., Technical Note No. 1143, Supplement*, September, 1947. 18 pp., tables. An expanded version of Table I, values of local Mach Number, pressure ratio, and pressure coefficient across shock waves.

Downwash and Wake Behind Untapered Wings of Various Aspect Ratios and Angles of Sweep. H. Page Hoggard, Jr., and John R. Hagerman. *U.S., N.A.C.A., Technical Note No. 1703*, October, 1948. 149 pp., illus., figs. 6 references.

Contains downwash-angle and dynamic-pressure-ratio contours behind ten different untapered wings of varying aspect ratio from 1.5 to 6.0 and sweep from 60° to −60°. The rate of change of downwash angle with angle of attack and effect of sweep are also shown. Data may be used for determining most suitable horizontal-tail positions.

Chordwise Pressure Distributions on a 12-Foot-Span Wing of NACA 66-Series Airfoil Sections Up to a Mach Number of 0.60. Nancy E. Wall. *U.S., N.A.C.A., Technical Note No. 1696*, October, 1948. 147 pp., illus., figs. 1 reference.

Chordwise pressure data showing the effects of Mach Number on the NACA 66-series sections of a 12-ft.-span wing. Pressure plots are presented for a Mach Number range from 0.20 to 0.60 and for an angle-of-attack range from −4° to the stalling angle of attack.

Gust-Tunnel Investigation of a 45° Sweptforward-Wing Model. Harold B. Pierce. *U.S., N.A.C.A., Technical Note No. 1717*, October, 1948. 14 pp., illus., figs. 5 references.

The acceleration increment obtained in a gust can be satisfactorily predicted from a slope of the lift curve obtained by multiplying the slope of the lift curve of the equivalent straight wing by the cosine of the angle of sweep and by using strip theory to estimate the penetration effect.

Loads on a Supersonic Wing Striking a Sharp-Edged Gust. M. A. Biot. *Cornell Aeronautical Laboratory, Report No. SA-247-S-7*, January 17, 1948. 19 pp., figs.

By direct integration of a variable distribution of sources in a fluid at rest, a simple formula is obtained for the pressure distribution on a supersonic wing striking a sharp-edged gust. The same expression can be obtained by using Busemann's method of conical flow. The time history of total lift and moment shows the largest value of total lift to be reached in the last phase—i.e., when a steady flow has been established. The maximum value of the mid-chord moment is reached when the Mach Number is larger than $4/\pi$. This absolute maximum moment is independent of the Mach Number. However, for Mach Numbers between $4/\pi$ and 1, the maximum mid-chord moment varies with the Mach Number and becomes infinite at Mach Number 1.

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BOEING

Airplane Design & Description (10)

Undercarriages for Deck Landing. J. W. Blinkhorn. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, pp. 304, 305, diagrs.

Outline of an approximate method of determining the vertical velocity of an aircraft at touch-down by correlating the maximum shock-absorber travel with laboratory drop tests, and an accurate method of determination in which the vertical velocity is calculated from the height-time curve plotted from motion-picture photographs of the landing gear during touch-down. Comparison of both kinds of measurements show the shock-absorber travel calculations to be confirmed by the photographic measurement.

Aerodynamics of High Speed Airplanes. K. E. Every. *SAE National Aeronautic Meeting, Los Angeles, October 6–9, 1948, Preprint.* 40 pp., figs. 17 references.

The practical aerodynamic problems encountered at transonic speeds. Raising the "effective" critical Mach Number of an airplane is a more efficient method of increasing speed than increasing the engine power or decreasing the parasitic drag. This higher Mach Number can be obtained by decreasing the wing thickness, decreasing the aspect ratio, sweeping the wings backward or forward, combining the airplane components to minimize interference effects, and by removing the boundary layer. The selection of wing plan form, airfoil section, type of empennage and its location, fuselage shape, wing-fuselage combination, fillets, fairing, and power-plant installation must ultimately be a compromise among the low- and high-speed control and stability, maximum lift, buffet limits, and stalling characteristics contributed by these components. The aerodynamic problems connected with the design of high-speed craft are fairly well defined, but further experimental and theoretical research and further correlation between wind-tunnel and flight tests are needed to arrive at practical engineering solutions and to establish design details.

Structural Aspects of High Speed Airplanes. Frank B. Sandgren. *S.A.E., National Aeronautic Meeting, Los Angeles, October 6–9, 1948, Preprint.* 7 pp. A discussion of the design problems that arise in the determination of loads and design criteria, in wing construction, sweptback wings, temperature effects, and in high-pressure vessels for aircraft intended to operate at transonic and the lower supersonic speeds.

Freighter to Airliner; Aer Lingus Converts (Douglas) DC-3s. *Modern Transport*, Vol. 60, No. 1540, October 2, 1948, p. 23, illus.

Let's Consider the Flapping Wing. Bill Stout. *Flying*, Vol. 43, No. 5, November, 1948, pp. 40, 60, 62, diagrs.

Problems of Certification—System Functioning. R. L. Thoren. *S.A.E., National Aeronautical Meeting, Los Angeles, October 6–9, 1948, Preprint.* 5 pp. An evaluation of the suitability of the various component systems of the present-day transport aircraft for use at the increased altitude, cruising speed, and rate of climb that are projected for transport aircraft in 1955.

New American Jets. A. Marthason. *The Aeroplane*, Vol. 75, No. 1949, October 15, 1948, pp. 499, 500, illus.

A Russian Notebook; Some General Observations on the Form and Organization of the Aircraft Industry of the U.S.S.R. Charles W. Cain. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, pp. 308–312, illus. 11 references.

L'Exhibition de Farnborough Vue par un Français; An Appreciation of the Recent Display Organized by the Society of British Aircraft Constructors at Farnborough During the Week September 7th–12th. André Charriou. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, pp. 290–292, illus.

Mighty Midgets. Curtis Fuller. *Flying*, Vol. 43, No. 5, November, 1948, pp. 22–24, 71, 72, illus. Goodyear Trophy Race winners, 1948.

Master Midgets. *Southern Flight*, Vol. 30, No. 4, October, 1948, pp. 12–15, 27, illus. Winning aircraft and records of the Goodyear Trophy Race at the 1948 National Air Races.

Twin-Quad (Beechcraft) Belly Keels Prevent Damage. *Airports and Air Carriers*, Vol. 14, No. 4, October, 1948, p. 20, illus.

Cal-Aero Designs Midget Jet; Low-Cost Craft, Suggested for Possible Military Use as a Drone, May Show the Way to a Personal Jet Plane. *Aviation Week*, Vol. 49, No. 17, October 25, 1948, p. 35, illus.

The Chrislea Super Ace. *The Aeroplane*, Vol. 75, No. 1949, October 15, 1948, p. 507, cutaway drawing.

New B-36 to Give USAF Greater Range (Convair B-36B). Robert Hotz. *Aviation Week*, Vol. 49, No. 16, October 18, 1948, pp. 12–14, illus. Description, specifications, and performance data for the Convair B-36B bombers.

In the Hercules Tradition (Handley Page 81 Hermes IV Transport). *Aeronautics*, Vol. 19, No. 5, October, 1948, pp. 30–37, diagrs.

Handley Page's Hermes IV (Transport). *The Aeroplane*, Vol. 75, No. 1947, October 1, 1948, pp. 447–452, illus., figs., cutaway drawing.

New Four-Engine Lightplane (Monsted-Vincent Star Flight). *Aviation Week*, Vol. 49, No. 16, October 18, 1948, p. 15, illus.

F-86 (North American) World's Fastest Fighter. Gaither Littrell. *Flying*, Vol. 43, No. 5, November, 1948, pp. 15–17, 49, illus.

For High-Lift Research (Youngman Full-Span Slotted Flap System). *The Aeroplane*, Vol. 75, No. 1947, October 1, 1948, pp. 445, 446, illus., cutaway drawings.

Airports & Airways (39)

The Medium Sized Aerodrome. J. H. Roddoch. *Airports & Air Transportation*, Vol. 3 (N.S.), No. 64, October, 1948, pp. 107–110. Licensing requirements, site selection, zoning and planning coordination, construction, drainage, turf, buildings, and sources of income for grass landing fields capable of accommodating aircraft in the 10,000-lb. class.

Airport Paving. *U.S. Department of Commerce, Civil Aeronautics Administration*, May, 1948. 54 pp., diagrs., figs.

Operational Research into the Air Traffic Problem. E. G. Bowen. *Institute of Navigation (London), Journal*, Vol. 1, No. 4, October, 1948, pp. 338–341, figs. 3 references. A discussion of the value of statistical analyses of arrivals at airports in the control of air traffic and the development of airports.

How to Winterize Airport Turf. George Milnes. *Airports and Air Carriers*, Vol. 14, No. 4, October, 1948, p. 12, illus.

Packaged Airports Expanded. *Airports and Air Carriers*, Vol. 14, No. 4, October, 1948, pp. 6–8, 10, 28, 31, illus., diagrs. Services supplied by Westinghouse International Company under a contract with the Turkish State Airways for the overall equipment requirements of ten airports.

Report on Port Authority Operation of Port Newark and Newark Airport, March 22, 1948, to September 21, 1948. *The Port of New York Authority, New York*, October 31, 1948. 32 pp., illus.

When Is a Public Airport Not a Public Airport? Tom Haire. *Airports and Air Carriers*, Vol. 14, No. 4, October, 1948, pp. 14, 15, illus. The financial problems of the privately owned airport might be solved by the enactment of legislation similar to that establishing The State Airways System of New Hampshire.

Construction of London Airport; Estimates Committee Urge New Programme. *Airports & Air Transportation*, Vol. 3 (N.S.), No. 64, October, 1948, pp. 80, 98. Proposed revision of construction schedule.

Airports of the World: Guernsey. Basil C. de Guerin. *Airports & Air Transportation*, Vol. 3 (N.S.), No. 63, October, 1948, pp. 85–87, illus.

Livingstone Airport, Northern Rhodesia. *The Aeroplane*, Vol. 75, No. 1949, October 15, 1948, pp. 508, 509, illus., diagr.

Airport Management—Job or Profession? John H. Frederick. *Southern Flight*, Vol. 30, No. 4, October, 1948, p. 32.

Merchandising Fuel and Oil (at Airports). Robb C. Oertel. *Southern Flight*, Vol. 30, No. 4, October,1948, pp. 30, 31.

Airport Buildings. II. (Brancker Memorial Lecture 1948.) J. W. S. Brancker. *Airports & Air Transportation*, Vol. 3 (N.S.), No. 64, October, 1948, pp. 94–98, diagrs. Layout, construction, and terminal operation.

Atomic Energy (48)

Atomic Power and Aircraft Propulsion. Andrew Kalitinsky. *Shell Aviation News*, No. 123, September, 1948, pp. 14–16, figs. (Extended summary of a paper.)

Aviation Medicine (19)

The Inconsistency of Pilot Performance in Approaching the Stall: Relationship to Flight Conditions, Experience, and Age.

P. J. Rulon.. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 79*, September, 1948. 185 pp., illus., figs., tables.

Students, private pilots, and instructors do not demonstrate possession of any dependable personal mechanism or method for determining the degree of loss in lift during a stall approach. Stall recognition appears to be specific to the flight condition in which it is attempted. There is apparently as much difference between pilot performance in two different makes of airplanes as there is in two different conditions of flight in the same airplane. Pilots who, under given conditions, perform best in normal flight in a familiar airplane are among those who depart most dangerously from normal flight in an unfamiliar airplane. To be skilled in recognizing stall incipience or in recognizing departure from normal flight in the direction of increased angle of attack, a pilot will do well to practice these things in the particular condition that interests him, in the particular airplane in which he wants the skill, and while equipped with an objective, impersonal means of judging his performance.

Comfortization (23)

Uitzichtmetingen (Visibility Measurements). T. v. Oosterom and J. A. Kok. *Netherlands, National Luchtvaartlaboratorium, Amsterdam, Rapport No. V.800a*, 1940. 46 pp., illus., figs., tables. 10 references.

A photographic method. It is applied to the measurement and the construction of charts showing the field of view from the pilot's cabin of a transport airplane.

Electronics (3)

Radio and Radar Equipment Employed by British Overseas Airways. G. C. Cunningham. *Shell Aviation News*, No. 123, September, 1948, pp. 10, 11, illus.

The Dry Voltaic Pile. A. Elliott. *Electronic Engineering*, Vol. 20, No. 248, October, 1948, pp. 317–319, figs. 9 references. Construction manufacture and properties of Zamboni Piles used to supply a potential difference to the electrodes of the image converter tube of an infrared telescope.

Theory of Electrical Bridges Applied to the Measurement of Dynamic and Static Mechanical Phenomena. Norman L. Laschever. *U.S., Army Air Forces, Technical Report No. 5631 (ATI No. 16256)*, July 25, 1947. 36 pp., figs.

Formulas are developed for the output voltage and current, for the maximum unbalance allowable consistent with linearity of output of single-active and multiactive arm unbalanced bridges and for the damping required by such bridges when used with direct-recording galvanometers. Attenuator and balancing-control design formulas are given for various d.c. bridge applications. Examples of typical d.c. bridge problems and a short discussion of the advantages, uses, and theory of a.c. bridges for dynamic measurements are included.

Electronic Digital Computers. III—The IBM Selective Sequence Calculator and the ENIAC. David Fidelman. *Radio & Television News*, Vol. 40, No. 5, November, 1948, *Radio-Electronic Engineering*, pp. 12–15, 30, illus., diagrs.

Etablissements Ora-Grandin, M. Chauchat, Metox. D. Nutting. *Combined Intelligence Objectives Sub-Committee, Item No. 1, File No. 1–2.* 7 pp. British Information Services, New York. $0.35

The Infra-Red Image Converter Tube. T. H. Pratt. *Electronic Engineering*, Vol. 20, No. 248, October, 1948, pp. 314–316, illus., diagrs.

Scattering of Ultrasonic Radiation in Polycrystalline Metals. W. Roth. *Journal of Applied Physics*, Vol. 19, No. 10, October, 1948, pp. 901–910, illus., diagr., figs. 19 references.

Engineering Practices & Aids (49)

An Electrical Instrument for Solving Second-Degree Algebraic Equations. G. C. Curtis. *Journal of Scientific Instruments*, Vol. 25, No. 10, October, 1948, pp. 341–343, figs.

Extensions in Differential Analyser Technique. J. G. L. Michel. *Journal of Scientific Instruments*, Vol. 25, No. 10, October, 1948, pp. 357–361, figs. 5 references.

Equipment

ELECTRIAL (16)

The Bridge Erosion of Electrical Contacts. I. J. J. Lander and L. H. Germer. *Journal of Applied Physics*, Vol. 19, No. 10, October, 1948, pp. 910–928, figs. 12 references.

Servicing Tips for (Delco-Remy) Generators. *Aviation Maintenance & Operations*, Vol. 10, No. 5, October, 1948, pp. 26, 27, 68, 70, illus.

Report on Robert Bosch G.m.b.H., Stuttgart, Germany. Kenneth Burnham. *Combined Intelligence Objectives Sub-Committee, Item No. 26, File No. 31–9.* 93 pp. British Information Services, New York. $2.50.

Advance Relays. *Advance Electric and Relay Company, Catalog, October*, 1948. 48 pp., illus., diagrs.

HYDRAULIC & PNEUMATIC (20)

The Sealing Mechanism of Flexible Packings. C. M. White and D. F. Denny. *Gt. Brit., Ministry of Supply, Scientific and Technical Memorandum No. 3/47*, January, 1947. 28 pp., illus., diagrs., figs. British Information Services, New York. $3.15.

An investigation to obtain fundamental knowledge of the mechanism by which packing devices prevent leakage. Experiments were conducted at the Civil Engineering Laboratories of the Imperial College to show how the pressure is distributed over the surface of flexible packings and how they deform under pressure. Extrusion of the material into the clearance space occurred with rectangular-section, otroidal, and U-section packings when the pressure difference was sufficiently great. Prolonged tests under severe working conditions showed that, although failure may take place in many different ways, it is usually caused either by abrasion against the cylinder or by fracture initiated by the groove corner. Modifications to the packings and grooves, such as bevelling or undercutting, and the use of backing rings of metal or other hard material were investigated as means for reducing this extrusion. Measurements of friction under widely different conditions disclosed a change of law as the speed increased which was attributed to the setting of film lubrication instead of the boundary type of lubrication that was obtained at lower speeds. The friction forces accorded with an algebraic analysis of the flow conditions between the packing and cylinder.

Flight Safety & Rescue (15)

Safety in the Skies; Navy's Transport Flying Record. Harold Bradley Say. *U.S. Naval Institute Proceedings*, Vol. 74, No. 547, September, 1948, pp. 1110–1119, illus.

Aluminum Foil Fire Fighting Suit Reflects Heat Radiation. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 21, November 1, 1948, pp. 8, 9, illus.

Methods for Prevention of Rocket Aircraft Fires. *U.S., Air Force, Technical Intelligence, Technical Data Digest*, Vol. 13, No. 21, November 1, 1948, pp. 9, 10.

Emergency Exit. *Aeronautics*, Vol. 19, No. 5, October, 1948, pp. 50, 51, diagrs. A discussion of the problem of escape from high-speed aircraft, describing the Martin-Baker ejection seat and proposed designs for jettisonable cockpit units.

Northolt Mid-Air Collision Inquiry. I. *The Aeroplane*, Vol. 75, No. 1947, October 1, 1948, pp. 456, 457.

Flight Testing (13)

The Vertical Component of Induced Velocity in the Plane of Symmetry of an Aeroplane. M. M. Callan. *Canada, National Research Council, Aeronautical Note No. An-1 (N/R/C.-1740, MA-163)*, 1948. 8 pp., figs. 4 references.

If the lift coefficient, aspect ratio, and span are given, the downwash ratio and, hence, the vertical component of the induced velocity in the plane of symmetry of an airplane may be found for any point behind and below the airplane from the curves that are given. Under certain conditions these curves will also hold for small departures from the plane of symmetry. The curves can be used to estimate the required positions of a trailing bomb used to determine the flight-path angle and the true air speed of an aircraft.

F-86A Hits Record; Cameras Miss; North American Swept-wing Fighter Tops D-558-1 Mark Before 80,000. Robert Hotz. *Aviation Week*, Vol. 49, No. 11, September 13, 1948, pp. 12, 13, illus.

Correctie van Vliegprestaties in Stationnaire Symmetrische Vlucht naar Gewenschte Omstandigheden van Atmosfeer, Gewicht en Motorregeling (The Correction of Flight Performance in Steady Symmetrical Flight to Desirable Conditions of Atmosphere, Weight, and Engine Regulation). H. J. van der Maas, S. Wynia, and A. J. Marx. *Netherlands, National Luchtvaartlaboratorium, Amsterdam, Rapport No. V. 1088*, October, 1940. 69 pp., fold. charts. 54 references.

Axial End-Piece. *Aeronautics*, Vol. 19, No. 5, October, 1948, pp. 44, 45, illus.

Description of the Lancaster II in which a Metropolitan-Vickers F 2/4 (Beryl) gas-turbine engine is mounted in the rear gun-turret position. The airplane is to be used as a flying test bed for the gas-turbine installation.

Fuels & Lubricants (12)

A Review of Aircraft Lubrication. II. E. E. Turner. *The Technical Instructor*, Vol. 3, No. 9, September, 1948, pp. 10–24, diagrs.

The use of H.D. or Additive 2 detergent oils; internal and external corrosion treatment of engines; lubrication of propeller pitch-change mechanisms, engine accessories, electric actuators, controls, hydraulic systems and instruments; and a classified list of fuels, oils, gear oils, hydraulic fluids, low temperature oils, greases, corrosion preventives, and antiseize compounds giving British and U.S. specification.

Étude sur l'Onctuosité des Lubrifiants (Study of the Oiliness of Lubricants). II. Fernand Charron. *France, Ministère de l'Air, Publications Scientifiques et Techniques No. 169*, 1940. 26 pp., illus., figs. Ed. Blondel la Rougery, Gauthier-Villars, Paris.

Gliders & Gliding (35)

Canadian Tailless; Details and Performance of the N.R.C. Glider. *Flight*, Vol. 54, No. 2076, October 7, 1948, p. 434.

Guided Missiles (1)

An Approximate Determination of the Lift of Slender Cylindrical Bodies and Wing-Body Combinations at Very High Supersonic Speeds. H. Reese Ivey and Robert R. Morrissette. *U.S., N.A.C.A., Technical Note No. 1740*, October, 1948. 18 pp., figs. 2 references.

A theory for extremely high supersonic flow is used to obtain a first approximation to the pressure distribution, lift, and drag due lift for a slender cylindrical body of revolution and a wing-body combination. The method is applicable only if the altitude of flight is low enough for the gas-dynamics type of flow to exist, if the angle of attack is large, and if the Mach Number is extremely large. For a body with a given diameter the lift is directly proportional to the body length. The lift of the circular body is approximately one-half that of a wing of the same plan area. The wing roots have extremely high pressures because they convert the flow around the local body sections into additional lift. The wing and the corresponding part of the body develop a combined lift equal to that of a continuous wing.

Probability That a Meteorite Will Hit or Penetrate a Body Situated in the Vicinity of the Earth. G. Grimminger. *Journal of Applied Physics*, Vol. 19, No. 10, October, 1948, pp. 947–956, figs. 15 references.

A preliminary attempt to estimate the probability of a body situated in the vicinity of the earth being hit by a meteorite and, when a hit does occur, to estimate the metal plate thickness necessary to prevent perforation by the impact of meteorites of different sizes. For stainless-steel skin of a thickness ranging from 0.05 to 0.02 in., it is necessary to consider meteorites as small as those corresponding to magnitude 8 and 11, respectively. In general, however, the probability of a hit is negligibly small, particularly if the body is not exposed to meteoritic impact for excessively long periods.

The Atomic Rocket. I. L. R. Shepherd and A. V. Cleaver. *British Interplanetary Society, Journal*, Vol. 7, No. 5, September, 1948, pp. 185–194. 1 reference.

The velocity requirements of a manned extraterrestrial vehicle make the use of chemical rocket fuels highly impractical. Velocities above 10 km. per sec., however, might be obtained economically by rockets employing nuclear energy. Since no method is known by which the arndom velocities of the products of nuclear fission can be converted to exhaust velocities, an intermediary working fluid would probably be required. Any nuclear rocket power plant would have to be shielded to prevent the development of excessive temperatures in the structures surrounding the power source and to protect the crew from radioactive radiations. The radiations of the power plant would also transmute the structural materials of the rocket and introduce further design problems. The lethal properties of the exhaust would cause problems in launching and landing.

Investigations of K-12 Automatic Pilot. Kagerer and Fuchs. (*Peenemünde, Heeresanstalt, Bericht Nr. 104, W VA/PA/86/104*, May 5, 1948.) *U.S., Air Force, Translation No. F-TS-2688-RE (ATI No. 19038)*, September, 1948. 10 pp., figs.

A progress report. The characteristic curves of the hydraulic system of the LGW (SAM) automatic pilot K-12 were developed without idealizing the curves for the pumps and showed satisfactory hinge-moment characteristics.

Guided Missiles. V. A. R. Weyl. *The Aeroplane*, Vol. 75, No. 1940, August 13, 1948, pp. 186–188, illus. Résumé of development projects at Peenemünde; Walter and BMW jet-engine development; and an analysis of the three phases of German guided-missile operations, strategic attack, operational attack, and direct defense.

Guided Missiles. VII. A. R. Weyl. *The Aeroplane*, Vol. 75, No. 1948, October 8, 1948, pp. 475, 476, 479, 480, illus., diagrs. German guided and semiguided antiaircraft missiles; and development in the U.S. and Gt. Britain.

Commercial Possibilities of Guided Missiles and Pilotless Aircraft. A. P. Gertz. *U.S. Air Services*, Vol. 33, No. 10, October, 1948, pp. 9, 11, 24.

The U.S. Naval Ordnance Test Station at Inyokern. L. J. Carter. *British Interplanetary Society, Journal*, Vol. 7, No. 5, September, 1948, pp. 177–184, illus.

Instruments (9)

Self-Detaching Cover for Pitot Tube Developed at AMC. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 21, November 1, 1948, p. 8, illus.

Sonde de Pression Statique (A Static-Pressure Head). J. Kampé de Fériet and G. Rollin. *France, Groupement Français pour le Développement des Recherches Aéronautiques, Note Technique No. 1*, January, 1939. 12 pp., diagrs., figs.

De Ijking van Stuwdruksnelheidsmeters van Vliegtuigen en de Herleiding Hunner Aanwijzing naar Werkelijke Snelheid (The Calibration of Aircraft Air-Speed Indicators and the Reduction of Their Indication to True Air Speed). S. Wynia and A. J. Marx. *Netherlands, National Luchtvaartlaboratorium, Amsterdam, Rapport No. V. 1165*, 1940. 12 pp., figs.

The Effect of the Staircase Scale on Dial Reading Accuracy. Julien M., Christensen. *U.S., Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Memorandum Report No. MCREXD-694-1-P*, October 1, 1948. 17 pp., figs. 2 references.

The Magnetic Compass: A Survey of Developments. W. E. May. *Institute of Navigation (London), Journal*, Vol. 1, No. 4, October, 1948, pp. 342–353, figs. 4 references.

The Gyrosyn Compass and Its Application to Automatic Approach. *The Technical Instructor*, Vol. 3, No. 9, September, 1948, pp. 3–9, diagrs., figs. Operation of the Sperry Gyrosyn Compass Type IV.B. and its function in the Sperry A-12 Gyropilot.

Apparatus for Measuring the Static Frictional Torques of Instrument Jewels. W. H. Pearse. *Journal of Scientific Instruments*, Vol. 25, No. 10, October, 1948, pp. 344–346, diagr. 2 references.

How to Use Time-Rite. Rev. Ed. *Gabb Manufacturing Co.*, September, 1948, 44 pp., diagrs.

Instruction booklet for the Griffiths Time-Rite piston-position indicator, a portable instrument for the precision timing of aircraft piston engines. The piston travel is measured directly by

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Laboratories, Aeronautical (50)

Dynamic Pressure Measurement by Optical Interference. Willard E. Buck and Walter H. Barkas. *Review of Scientific Instruments*, Vol. 19, No. 10, October, 1948, pp. 678–684, diagrs., figs.

A pressure gage in which the displacement of a pressure diaphragm is measured by recording photographically the motion of interference fringes formed by light reflected from the diaphragm and from an adjacent stationary mirror. The instrument has an absolute error of less than 0.5 per cent over a frequency range from 0 to above 10,000 cycles per sec. at pressures from 0 to 5,000 lbs. per sq.in. Calibration is carried out under static conditions and the response is linear.

Automatic Plotting of Electrostatic Fields. Paul E. Green, Jr. *Review of Scientific Instruments*, Vol. 19, No. 10, October, 1948, pp. 646–653, illus., diagrs., figs. 2 references.

The usual electrolytic-tank method has been extended by the addition of a servomechanism that causes the probe to traverse an equipotential automatically, thus permitting the equipotentials of two-dimensional fields to be plotted automatically. A stepping relay operated by a limit switch effects automatic plotting of successive equipotentials and limits the plot to a desired area.

An Electrokinetic Transducer. Milton Williams. *Review of Scientific Instruments*, Vol. 19, No. 10, October, 1948, pp. 640–646, diagrs., figs. 4 references. A transducer that utilizes the electrokinetic potential developed by the movement of a fluid through a porous solid for the transformation of sonic to electrical energy.

Machine Elements (14)

Effects of Temporal Tangential Bearing Acceleration on Performance Characteristics of Slider and Journal Bearings. Dezso J. Ladanyi. *U.S., N.A.C.A., Technical Note No. 1730*, October, 1948. 32 pp., figs. 7 references.

The derivation of the mathematical expressions for the effects of temporal tangential bearing acceleration begins with the laws of classical hydrodynamics and concludes with modified versions of the usual performance equations in lubrication. These modified equations establish fundamental relations and show the effects of this type of acceleration on pressure distribution and load capacity. Nomographs are included to facilitate the solution of practical problems. The most important factor in establishing the effect of acceleration on bearing performance characteristics is the ratio of acceleration to speed. When this ratio is high, the effect of acceleration is large; when it is low the effect is small. Acceleration acts to decrease the load capacity of a bearing and in certain cases its effects are as important as those caused by lubricant viscosity.

Eliminating Vibration in High-Speed Machines. Alfred S. Gutman. *Machine Design*, Vol. 20, No. 10, October, 1948, pp. 118–124, diagrs. 1 reference.

Design of a mount for a rotating antenna that always operates out of the critical speed range. A pneumatic tube and an Oldham coupling permit lateral displacement of the drive shaft which allows the center of gravity to seek the center of rotation.

Maintenance (25)

How to Splice a Wooden Spar. *Aviation Maintenance & Operations*, Vol. 10, No. 5, October, 1948, pp. 37–40, illus.

Management & Finance (45)

Flexible Financing for Aircraft Distribution. H. A. Shaffer. *Southern Flight*, Vol. 30, No. 4, October, 1948, p 33.

Materials (8)

Directory of Materials. 15th Edition. *Machine Design*, Vol. 20, No. 10, October, 1948, pp. 223–280.

All types of materials used for fabrication into machine parts are listed by trade name. Each listing includes the type of material, name of producing company, material analysis, and brief data on properties, characteristics, and representative machine applications. The list includes metals, plastics, and nonmetallics. Standard stainless steels are listed separately by the standard AISI types. A list by trade names and producing companies gives the types of steel and the forms that are available. A cross index for comparing similar materials and for selection based on the major alloy constituent is provided for by an index of materials by type. The names and complete addresses of producers, along with types and trade names of the materials they produce, are given in an alphabetical list of materials producers.

METALS & ALLOYS

Symposium on the Welding of Light Alloys: Further Examination of the Tensile Strength of Gas Welds in a Magnesium-Manganese Alloy. J. Pendleton. *Sheet Metal Industries*, Vol. 25, No. 258, October, 1948, pp. 2049–2052, illus.

The scatter of tensile strength of welds in magnesium-manganese alloy is associated with variations in grain size of the basis metal immediately adjacent to the weld. This grain size is largely a function of time at elevated temperature, and any tacking or restarting that increase this time is liable to produce abnormal grain growth. The addition of small amounts of cerium or calcium limits grain growth in the basis metal, but alloys containing these additions have a tendency to crack. Misalignment has a seriously detrimental effect on the strength of gas welds in magnesium-manganese alloys.

Plate Compressive Strength of FS-1h Magnesium-Alloy Sheet and a Maximum-Strength Formula for Magnesium-Alloy and Aluminum-Alloy Formed Sections. George L. Gallaher. *U.S., N.A.C.A., Technical Note No. 1714*, October, 1948. 23 pp., diagrs., figs. 9 references.

The plate compressive strength of FS-1h magnesium-alloy sheet was determined from local-instability tests of formed Z-section columns. The critical compressible stress was found to correlate well with the compressive stress-strain curve for the material. The average stress at maximum load plotted against the calculated critical strain resulted in a family of curves similar to those for aluminum-alloy sheet. An empirical formula was developed for calculating the average stress at maximum load for formed Z-sections and channel sections of FS-1h magnesium-alloy sheet and 24S-T and 17S-T aluminum-alloy sheet.

The Bending Modulus of Rupture of Round Magnesium Tubing. C. H. Mortenson. *Journal of the Aeronautical Sciences*, Vol. 15, No. 11, November, 1948, pp. 661–664, illus., figs. 1 reference.

Test conditions and results of bend tests conducted on round FS-1a and Ma magnesium-alloy tubes. A formula is established for minimum and average bending strength.

High Quality Steel Castings, Ruhrstahl A. G., Annen. H. Sulton. *Combined Intelligence Objectives Sub-Committee, Item No. 21, File No. 31–42.* 16 pp. British Information Services, New York. $0.55.

High-Temperature Ceramic Coatings for Molybdenum. *U.S., National Bureau of Standards, Technical Report No. 1296*, October, 1948. 6 pp., illus. 1 reference.

A ceramic coating containing zirconia fired in an oxygen-free atmosphere gave, in simulated service tests, a life in excess of 45 min. to molybdenum pitot tubes built into the nozzle end of ram-jet engines where they are subjected to a gas temperature of about 3,000° F.

A New Nimonic Blade Material. *The Aeroplane*, Vol. 75, No. 1948, October 8, 1948, pp. 481, 482, illus.

Physical properties of Nimonic 80A and data from creep and tensile tests. This nickel-chromium alloy can be used for relatively short-time service at temperatures from 820° to 850°C. and has improved load-carrying capacity at lower temperatures.

Low-Temperature Properties of 18:8 Chromium-Nickel Steel. *U.S., National Bureau of Standards, Technical Report No. 1285*, October, 1948. 8 pp., illus., figs. 1 reference.

Austenitic, metastable austenitic, and ferritic steels of 18:8 Cr-Ni composition, both with and without additions of Mb, Ti, and Co, were subjected to tension tests at temperatures ranging from room temperature to —188°C. The automatic load-extension diagrams from the tests showed a change of phase during the plastic deformation of the metastable austenitic

steels which became increasingly rapid as the temperature decreased.

Obtaining Fatigue-Test Data. J. A. Sauer and P. K. Roos. *Machine Design*, Vol. 20, No. 10, October, 1948, pp. 115–117, 158, 160, 162, illus., figs.

Modifications of the Sonntag fatigue-testing machine; test procedure; and test data used to obtain, in the study of nut-bolt action under various types of vibratory conditions, the effect of induced fatigue cracks on the mechanical properties of materials and the effect of simultaneous bending and torsional moments on the fatigue characteristics of a given material.

The Flow of Metals Under Various Stress Conditions. A. L. Nadai. *Institution of Mechanical Engineers, Proceedings, Vol. 157, Excerpt from War Emergency Issue No. 28*, 1947. pp. 121–160, illus., figs. 75 references.

Aircraft Refuelling During Flight. *Aero Research Technical Notes, Bulletin No. 69*, September, 1948, pp. 1–6, illus. The use of the Redux process to bond brass to brass in the fabrication of the contact line container of the tanker aircraft used in flight and refueling operations.

Alloying of Metal Powders by Diffusion. Sidney Weinbaum. *Journal of Applied Physics*, Vol. 19, No. 10, October, 1948, pp. 897–900, diagr., figs. 5 references.

In the preparation of alloys by sintering metal powders, the alloy is formed by the diffusion of metals into each other. The distribution of metallic powder in space is expressed by means of a triple series; this series is used to obtain the solution of the diffusion equation. The resulting formula gives the concentration of metal as a function of space, time, temperature, and particle size. Sample calculations made for one-to-one atomic proportion nickel-copper alloys are in general agreement with experimental results.

Steels and Their Treatment. I—Selection. Norman N. Brown. *Machine Design*, Vol. 20, No. 10, October, 1948, pp. 87–92, 152, 154, illus.

High-Temperature Attack of Various Compounds on Four Heat-Resisting Alloys. D. G. Moore, J. C. Richmond, and W. N. Harrison. *U.S., N.A.C.A., Technical Note No. 1731*, October, 1948. 19 pp., figs. 2 references.

In order to determine the possibility of preparing a ceramic coating to improve the corrosion susceptibility at high temperatures of high-molybdenum alloys, Hastelloy B, S-816, S-590, and Haynes Stellite No. 21 alloys were maintained at a temperature of 1,500°F. for 17 hours in the presence of various compounds to ascertain their corrosive attack on the alloys. Hastelloy B was found to be the most susceptible to attack by the more corrosive coating ingredients when heated in air but was not corroded in atmospheres of carbon dioxide or helium. Alkalies, lead compounds, and some of the alkaline earths showed the most corrosive action. Results indicate that it should be possible to prepare satisfactory ceramic coatings for these metals.

NONMETALLIC MATERIALS

Plastic Plane; Maryland Firm (Golladay Aeronautical Laboratory, Cumberland, Md.) Working with New Method That Resembles Casting. *Aviation Week*, Vol. 49, No. 17, October 25, 1948, p. 23.

Design and Application of Glass-Reinforced Plastic Parts. Roger White. *Machine Design*, Vol. 20, No. 10, October, 1948, pp. 103–107, 156, illus., diagrs.

SANDWICH MATERIALS

On a Theory of Sandwich Construction. W. S. Hemp. *College of Aeronautics, Cranfield, England, Report No. 15*, March 1948. 10 pp., figs. 3 references.

The theory proceeds from the simple assumption that the filling of the sandwich is homogeneous but anisotropic and that it has only transverse direct stiffness and shear stiffness corresponding to its functional requirements. This supposition permits the integration of the equilibrium equations for the filling. The resulting integrals are used to study the compression buckling of a flat sandwich plate. In a second approach to sandwich problems, a generalization of the usual theory of bending of plates, making allowance for flexibility in shear, is applied to overall,

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compression buckling of a plate. Since these latter results agree with those previously obtained by the more accurate method, the second approach can be used in problems involving the buckling of curved shells. Its application to the symmetrical buckling of a circular cylinder in compression is illustrated.

Theory and Practice of Sandwich Construction in Aircraft, A Symposium. (Institute of the Aeronautical Sciences, 16th Annual Meeting, New York, January 26–29, 1948.) *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 165,* 1948. 100 pp., illus., diagrs., figs. $2.50.

Contents: Introductory Remarks, Martin Goland; Research on Sandwich Constructions at Forest Products Laboratory, C. B. Norris; The Buckling of Sandwich Structural Elements, N. J. Hoff; Contributions to the Problem of Structural Analysis of Sandwich-Type Plates and Shells, E. Reissner; A Small-Deflection Theory for Flexurally Orthotropic Flat Sandwich Plates, C. Libove; Experiences with Sandwich Materials in Air Frames, H. B. Gibbons and E. MacDonough; Sandwich Materials Metal Honeycomb Cores, T. P. Pajak and H. C. Engle; Remarks About the Detail Design and Use of Honeycomb Construction, E. J. Weber; Use of Sandwich Construction in Military Aircraft, R. Schwartz; General Discussion.

Shear Flows in Multicell Sandwich Sections. Stanley U. Benscoter. *U.S., N.A.C.A., Technical Note No. 1749,* November, 1948. 28 pp., figs. 5 references.

Determination of various relations between cellular shear flows and cell twists that may exist physically in a multicell sandwich plate. Solutions are given for the distribution of shear flows required to preserve continuity of the warping displacements when the rate of twist varies from cell to cell in various manners. Symmetrical shear-flow distributions provide a resultant torque on the section but no resultant shear. Antisymmetrical distributions give neither a resultant shear nor a torque and, hence, are self-equilibrating. A formula is also derived for the torsion constant of a sandwich section with any number of cells.

Meteorology (30)

A Technical Report on the Formation of Typhoons. Herbert Riehl. (*NavAer 50-1R-223.*) *U.S., Navy, Chief of Naval Operations, Aerology Flight Section, Reprint,* August, 1948. 27 pp., figs. 25 references.

As part of an examination of the structure of the "equatorial front" in the western Pacific, a typical example of cyclogenesis in the western tropical Pacific Ocean was investigated. Low-troposphere data did not support the concept of an equatorial fron extending across the entire Pacific Ocean but showed the presence of several large clockwise rotating eddies in the equatorial trough. Typhoon development began as a consequence of the instability of the northern hemisphere trades and not as a result of interaction between currents from northern and southern hemispheres. At 200 millibars, instead of the easterlies characteristic of low levels, large vortices were found which constituted a system of the order of magnitude of long waves in the westerlies. The high-tropospheric vortices and the waves in the easterlies, although not propagated at the same speed, maintained a relative motion. Instability of the trades set in just as a lower wave trough was by-passed by a broadscale ridge in the high troposphere. The pressure field that the upper vortices superimposed on the low levels appeared to explain the instability of the trades.

State of the Upper Atmosphere. S. L. Seaton. *Journal of Meteorology,* Vol. 5, No. 5, October, 1948, pp. 204–219, figs. 21 references.

A theory is outlined whereby measurements of the ionosphere may be used to deduce the various quantities descriptive of the state of the atmosphere between 90 and 400 km. World-wide isopleths constructed from data obtained from 18 widely separated locations show that cells of high and low temperature are systematically developed in northern and southern hemispheres. The recombination coefficient between electrons and positive ions is not pressure-sensitive within an ionospheric layer, and the recombination coefficient is not dependent upon the electron density. Temperature gradients that were found suggest strong wind systems, pronounced convection currents, and considerable turbulence.

The Production of Rain by a Chain Reaction in Cumulus Clouds at Temperatures Above Freezing. Irving Langmuir. *Journal of Meteorology,* Vol. 5, No. 5, October, 1948, pp. 175–192, fig., tables. 12 references.

On the Production of Kinetic Energy in the Atmosphere. Victor P. Starr. *Journal of Meteorology,* Vol. 5, No. 5, October, 1948, pp. 193–196. 4 references.

The production of kinetic energy in the atmosphere is examined from a hydrodynamical point of view. The results indicate that the intensity of the primary source of horizontal kinetic energy at any point in the atmosphere is equal to the pressure multiplied by the horizontal divergence of the velocity. Regions of horizontal velocity convergence appear as hydrodynamical sinks for kinetic energy, in addition to frictional effects. Kinetic energy may be transferred through advection and through work done by pressure forces. It appears that diverging anticyclones are of primary importance in providing kinetic energy for the general circulation.

A Study of the Mean Wind and Temperature Distribution in the Vicinity of the Polar Front in Winter. E. Palmen and C. W. Newton. *Journal of Meteorology,* Vol. 5, No. 5, October, 1948, pp. 220–226, figs. 4 references.

A mean cross section is constructed from a number of individually analyzed daily cross sections, using the frontal layer as a reference for the coordinates. This preserves the thermal gradients observed in the individual cases and minimizes the effect of observational errors. Computed wind velocity, wind shear, and vorticity patterns are discussed, particularly with regard to the strong anticyclonic shear and low absolute vorticity found to the south of the jet stream near the tropopause level.

A New Tendency Equation and its Application to the Analysis of Surface Pressure Changes. Warren L. Godson. *Journal of Meteorology,* Vol. 5, No. 5, October, 1948, pp. 227–235, figs. 11 references.

Turbulence Over the Colorado Mountains. Forest E. Horning. *Colorado, Division of Aeronautics, Denver,* 1948. 10 pp., charts.

Construction of Isobaric Charts for the Isopycnic Level. Mariano Doporto. **A Statistical Analysis of the Comparative Accuracy of Estimates of Winds at 1 KM. Using Surface Charts and a 8 KM. Using Isopycnic Charts.** W. A. Morgan. *Ireland, Meteorological Service, Technical Note No. 8 (Advance Issue),* 1948. 37 pp., fold. charts. 6 references.

The Behavior of Barometric Pressure During and After Solar Particle Invasions and Solar Ultraviolet Invasions. B. Duell and G. Duell. *Smithsonian Institution, Miscellaneous Collections,* Vol. 110, No. 8 (Publication No. 3942), August 5, 1948. 34 pp., figs. 42 references.

Is Forecasting Necessary? Francis Chichester. *Institute of Navigation (London), Journal,* Vol. 1, No. 4, October, 1948, pp. 354–361, Discussion, pp. 361–365, figs.

A Thermodynamic Analysis of Cumulus Convection. James M. Austin and Aaron Fleisher. *Journal of Meteorology,* Vol. 5, No. 5, October, 1948, pp. 240–243, figs. 3 references. An investigation to determine, for different mixing régimes, the lapse rates of temperature and liquid-water content in the cloud; and a discussion of the application of these factors to cumulus growth.

Les Conditions Météorologiques dans la Haute Troposphère (à 5,000 Mètres et Au-Dessus) Considérées en Vue de la Navigation Aérienne (Meteorological Conditions in the Upper Troposphere (5000 Meters and Above) and the Flight of Aircraft). Georges Barbe. *France, Groupement Français pour le Développement des Recherches Aéronautiques, Rapport Technique No. 1,* 1939. 30 pp., figs.

Military Aviation (24)

B.E.A. to Berlin. II—Visits to Gatow Control, Wunstorf and Lübeck: Soviet Aircraft Encountered. H. F. King. *Flight,* Vol. 54, No. 2076, October 7, 1948, pp. 429–433, illus.

Berlin Airlift. Charles L. Saperstein. *Distribution Age,* Vol. 47, No. 10, October, 1948, pp. 20, 21, 90, illus.

Will Subs Launch the Atom Air War? J. William Welsh. *Flying,* Vol. 43, No. 5, November, 1948, pp. 20, 21, 50, 52, illus.

Navy to Build Super Aircraft Carrier (the Flush-Deck 65,000-Ton CVA-58). *U.S., Air Force, Air Technical Intelligence, Technical Data Digest,* Vol. 13, No. 21, November 1, 1948, pp. 5–7, illus.

Air Defense Command. George E. Stratemeyer. *U.S. Air Services,* Vol. 33, No. 10, October, 1948, p. 12, 14, 24.

2 APPLICATION
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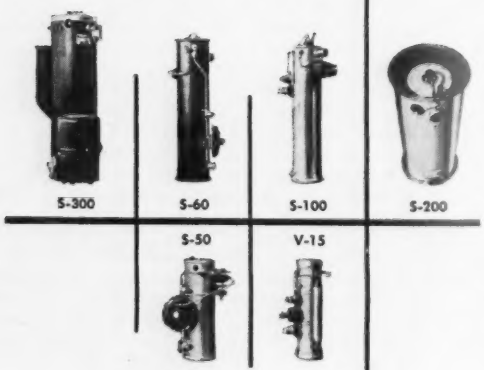

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Supplying the Air National Guard. Howard Mehr. *Aviation Maintenance & Operations*, Vol. 10, No. 5, October, 1948, pp. 28, 29, diagrs. Organization and procurement procedures of the 106th Bomb Group (Light) of the Air National Guard, New York.

Naval Aviation and the Influence of its Mission on Carrier-Based Aircraft. T. C. Lonnquest. *Aeronautical Engineering Review*, Vol. 7, No. 11, November, 1948, pp. 18–28, illus.

An outline of the major operational aspects of a future war, showing the role of sea-air power in national defense and a survey of the influence exerted on the design of carrier-based aircraft by the space limitations of the carrier; by the unique combat conditions in which the Carrier Task Force operates; and by the necessity for providing the pilot of fighter and attack aircraft with a habitable cockpit environment, electronic and mechanical extension of his sensory faculties, and means of emergency escape at high speeds.

Navy Logistics Support by Air. *The Martin Star*, October, 1948, pp. 8, 9, 18, 19, illus. Navy policy with respect to the peacetime use of air transportation.

Navigation (29)

The Presentation of the Fixing Accuracy of Navigation Systems. G. H. Trow and A. H. Jessell. *Institute of Navigation (London), Journal*, Vol. 1, No. 4, October, 1948, pp. 313–337, figs. 3 references.

The best general picture of the accuracy provided by a navigation system can be presented diagrammatically by contours of constant 95 per cent radial error. Where a more detailed picture is required, error ellipses can be added at suitable points in the system. The 95 per cent radial error of fixing is calculated for radial, $r\theta$, azimuthal, and different hyperbolic systems. Graphical methods are developed for drawing contours along which the 95 per cent error is constant and also for drawing 95 per cent ellipses. Diagrams show typical results for the different systems.

Operations

COMMERCIAL (41)

Performance and Direct Flying Costs of Commercial Aviation. G. Vejde. (*Teknisk Tidskrift* (Stockholm), Vol. 76, No. 24, June 15, 1946.) *Sweden, Kungl. Flygförvaltningen (Royal Swedish Air Board, RSAB), Translation No. 3*, 1947. 24 pp., figs. (In English.)

A survey of the development and a comparison of the present traffic density, operating costs, and rates of the Swedish and U.S. commercial air lines. By using minimum climbing performance as an index of aircraft performance, the four-engined transport is shown to be superior to the two-engined aircraft for short, medium, and long hauls. A comparison of the direct flying costs of various aircraft designs shows a wide variation in operating efficiency. Improved design during the past 10 years has reduced these costs by one-half. The continuation of this trend holds promise of greater efficiency, which will permit lower rates, broaden the base of the traffic potential, and allow the expansion of the industry.

Plain Talk on a Top Drawer Theme. Allan F. Bonnalie. *U.S. Air Services*, Vol. 33, No. 10, October, 1948, pp. 7, 8.

The regulations under which the nonscheduled air lines operate have made it possible for them to offer passenger fares substantially below those of the certificated carriers. These rates reflect lower operating costs that are possible because the nonscheduled lines do not have to maintain intermediate stations and facilities, their pilots do not have to be qualified in detail in several routes and on all regular and alternate airfields, their reservations problem is simple, and they do not have to maintain complex radio and ground-wire communication systems. Although the nonscheduled operators take a substantial amount of traffic from the certificated lines, they are meeting a public demand, because it is estimated that 80 per cent of their total passengers would not fly if the rates were higher. The regular carriers could provide a similar low-cost service, but this would enormously complicate their accounting problem because they could assess to this type of operation only those costs applicable thereto.

Timetable Planning; Second Aer Lingus Experiment; Cheaper Fares and Adjusted Schedules. *Modern Transport*, Vol. 60, No. 1542, October 16, 1948, p. 9.

Finnish Air Transport; Operations of Aero O/Y. *Modern Transport*, Vol. 60, No. 1542, October 16, 1948, p. 11, illus.

Scandinavian Airlines System. *Shell Aviation News*, No. 123, September, 1948, pp. 8, 9, illus.

Air Transport Problems. Emory S. Land. *Distribution Age*. Vol. 47, No. 10, October, 1948, pp. 35, 73–75.

Aircargo Handling Marches On. Randall R. Howard. *Distribution Age*, Vol. 47, No. 10, October, 1948, pp. 22, 23, 85, illus. New specialized handling methods adopted by Air Cargo Inc.

Motaircargo in High Gear. John H. Frederick. *Distribution Age*, Vol. 47, No. 10, October, 1948, pp. 19, 57, illus.

Streamlined Baggage Loading. *Aviation Maintenance & Operations*, Vol. 10, No. 5, October, 1948, p. 30, illus. Pan American World Airways System's conveyer system.

Meals Not Included in Price of Ticket. E. V. Rickenbacker. *Airports and Air Carriers*, Vol. 14, No. 4, October, 1948, p. 11.

Preparing for Service. II. *The Aeroplane*, Vol. 75, No. 1947, October 1, 1948, pp. 453–455, illus. Development trials and preparations that must be made by air lines when putting new aircraft into service.

The Commonwealth Reserve Route, (Australia–England). *The Aeroplane*, Vol. 75, No. 1948, October 8, 1948, pp. 484, 485, map.

Economics of Civil Aviation; Safety and Speed Factors. Peter G. Masefield. *Modern Transport*, Vol. 60, No. 1541, October 9, 1948, pp. 21, 22, fig.

Some Economic Factors in Civil Aviation; The Annual British Commonwealth and Empire Lecture by Peter G. Masefield Before the Royal Aeronautical Society. *Flight*, Vol. 54, No. 2076, October 7, 1948, pp. 435–437, tables. (Extended summary of a paper.)

Some Economic Factors in Civil Aviation. III. Peter Masefield. *Flight*, Vol. 54, No. 2077, October 14, 1948, pp. 463–465, 470, figs., tables. (Extended summary of a paper.) Fixed and operating costs for seven representative commercial aircraft and the comparative economy of various types of power plants.

CAB and Aircargo Competition. John H. Frederick. *Distribution Age*, Vol. 47, No. 10, October, 1948, pp. 36, 76–78, illus. An analysis of the C.A.B. minimum rate order and its probable effects.

Ordnance & Armament (22)

Self-Marking Target Towed by Aircraft (Svenska Aeroplan Aktiebolaget). *Antiaircraft Journal*, Vol. 91, No. 5, September-October, 1948, p. 51.

Photography (26)

Experiment in Large Scale Mapping Using Multiplex Method. K. B. Wood and S. B. Gross. *Photogrammetric Engineering*, Vol. 14, No. 3, September, 1948, pp. 357, 358. Mapping a tidal deep-water channel with elevations accurate to 0.5 ft.

Master Parallax Graph. H. R. Paterson. *Photogrammetric Engineering*, Vol. 14, No. 3, September, 1948, pp. 409–413, figs.

The Master Parallax Graph accurately converts parallax differentials to differences of elevation. It is constructed for a flying height of 10,000 ft., and the conversion factors that are indicated must be used for other altitudes. Elevation differences can be read to an accuracy of one two-thousandth of the altitude.

Selections of Camera Stations in Terrestrial Photogrammetry. Everett L. Merritt. *Photogrammetric Engineering*, Vol. 14, No. 3, September, 1948, pp. 421–424, figs. 3 references.

Field Calibration of Aerial Mapping Cameras. Eldon D. Sewell. *Photogrammetric Engineering*, Vol. 14, No. 3, September. 1948, pp. 363–398, illus., figs.

A Functional Comparison of Stereoscopic Plotting Instruments. R. J. Sparling and J. V. Sharp. *Photogrammetric Engineering*, Vol. 14, No. 3, September, 1948, pp. 358–362, fold. chart.

Power Plants

Heat Transfer and Temperature Profiles in Laminar Boundary Layers on a Sweat-Cooled Wall. E. R. G. Eckert. *U.S.*,

Army Air Forces, Technical Report No. 5646 (ATI No. 28681), November 3, 1947. 12 pp., figs. 4 references.

After a detailed discussion of the physical processes that take place in a porous wall that is cooled by forcing a gas through the pores from the cool to the hot side of the wall, the heat transfer from the hot medium to the wall is calculated for two-dimensional stationary flow with laminar boundary layer. The properties of the medium flowing outside the wall and the cooling medium flowing through the pores are assumed constant and of the same magnitude for both media. An analytical derivation is obtained for the general case when the velocity outside the boundary layer varies according to an exponential function. Numerical calculations are made for the flow along a flat plate and for flow near the stagnation point which show that, on a flat plate, an average exit velocity of the coolant, which equals 1 per cent of the outside flow velocity, reduces the heat transfer to one-tenth the value obtained without sweat-cooling.

American Aircraft Propulsion Machinery. W. J. King and W. R. Hawthorne. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 29*, 1947, pp. 197–202, illus., figs. 9 references.

The Aviation Engine Position. F. R. Banks. *The Aeroplane*, Vol. 75, No. 1949, October 15, 1948, pp. 501, 502, illus.

New Propeller Engines for the Air Force (Wright T-35 Typhoon Turboprop and Pratt & Whitney R-4360-VDT Engines). *Aviation Week*, Vol. 49, No. 17, October 25, 1948, p. 18, illus.

Robert Bosch and Deckel Co. A. T. Priddle and C. B. Dicksee. *Combined Intelligence Objectives Sub-Committee, Item Nos. 19, 26, File No. 33, 13.* 127 pp., diagrs., figs. British Information Services, New York. $6.30.

A survey made in June of 1945 of the activities of Robert Bosch, G.m.b.H. and the Deckel Company, Munich, in the design, development, and production of fuel injection pumps, nozzles, governors and timing controls, and filter systems for Diesel, spark-ignition, and turbine combustion engines; electrical equipment; and production control and research instruments. Details are given of a device that uses a bell and plunger unit as the elements of an electrical condenser for measuring clearances in the order of 1–10μ in pump elements; of a method of depositing metallic coating on paper condenser elements by a vaporization process; and hot-bomb and cold-bomb instruments for observing the ignition of the injected fuel spray. The cold-bomb equipment includes a photographic device with a picture interval of 10^{-4} sec. and spark illumination of 10^{-7} sec. duration.

JET & TURBINE (5)

The Development of an Axial Flow Gas Turbine for Jet Propulsion. D. M. Smith. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 36*, 1947, pp. 471–482, Discussion, pp. 491–497, diagrs., figs. 6 pp. of illus. 6 references.

A review of the technical development and the evolution of the F2/4 axial-flow, straight-through, annular-combustion chamber jet engine designed and manufactured by the Metropolitan-Vickers Electrical Company, Ltd. The preliminary work on the application of gas turbines to aircraft propulsion was done in 1938–1939 in collaboration with the Royal Aircraft Establishment and the development of a simple axial-flow jet engine was started in 1940. First bench tests were run in December of 1941 and flight tests on a flying test bed were made in the spring of 1943. In November of the same year the engine was tested in a jet-propelled aircraft.

Contribution to the Theory and Performance of Ram Jets. Demetrios Samaras. *Canada, National Research Council, Aeronautical Report No. AR-3 (N.R.C. 1674)*, 1948. 23 pp., figs. 27 references.

A discussion of the gas-dynamic processes that take place during the operation of the ram-jet power plant at subsonic and supersonic velocities. The external and the internal pressure losses are shown to be suitable indices of the performance of the engine. By choice of suitable parameters the performance of any ram-jet may be found from three simple charts. These show that at subsonic velocities the overall pressure efficiency is more important than combustion efficiency because the performance deteriorates rapidly with a slight decrease of the overall pressure efficiency. At supersonic speeds, however, the opposite is true. Three variables are available for the control of a simple ram-jet: the quantity of fuel, the inlet area, and the propelling nozzle area.

Thermodynamic Performance Considerations of Jet Propulsion. D. G. Samaras. *Canada, National Research Council, Division of Mechanical Engineering, Report No. ME-57*, February, 1942. 61 pp., figs. A study of the adiabatic and isothermal cycles, both simple and regenerative, and calculations of the efficiency of jet engines and the performance characteristics of jet-propelled aircraft.

Power Plant Development. E. W. Still. *The Aeroplane*, Vol. 75, No. 1949, October 15, 1948, p. 495. (Summary of a paper.)

The Development of Gas Turbine Power Plants for Traction Purposes in Germany. R. H. Bright. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 34*, pp. 375–382, Discussion, 383–386, diagrs., figs.

Aeroplane Gas Turbines. Hayne Constant. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 29*, 1947, pp. 202–204.

Gas Turbines in the United States; Impressions of a Tour of American Gas Turbine Plants and Laboratories: Progress Analyzed. P. F. Martinuzzi. *Flight*, Vol. 54, No. 2076, October 7, 1948, pp. 439–441, illus.

Bristol "Proteus" Propeller Turbine. *Shell Aviation News*, No. 123, September, 1948, pp. 22, 23, illus.

Testing the (de Havilland Mk. 2) Goblin. *Shell Aviation News*, No. 123, September, 1948, p. 20, illus.

A Contribution to the Solution of the Gas Turbine Problem. A. J. R. Lysholm. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 36*, 1947, pp. 498–513, Discussion, pp. 514–523, diagrs., figs. The development and application of the Ljungström compressor and turbine in stationary and aircraft power plants.

New Wright "Turbo-Cyclone 18" Ordered by Navy. *U.S. Air Services*, Vol. 33, No. 10, October, 1948, p. 17, illus.

The Measurement of Errors in Gears for Turbine Reduction Drives. C. Timms. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 36*, 1947, pp. 418–432, Discussion, pp. 432–451, illus., diagrs., figs.

Progress in Turbine Gear Manufacture in Recent Years. A. Sykes. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 35*, 1947, pp. 405–417, Discussion, pp. 437–451, diagrs., figs. 4 pp. illus.

Jet Engine Shipped Safer by New Packaging Method (Edo Corp.). *Aviation Week*, Vol. 49, No. 17, October 25, 1948, pp. 24, 25, illus.

RECIPROCATING (6)

Performance of Exhaust-Gas Blowdown Turbine and Various Engine Systems Using a 12-Cylinder Liquid-Cooled Engine. Leland G. Desmon and Eldon W. Sams. *U.S., N.A.C.A., Technical Note No. 1735*, November, 1948. 37 pp., illus., figs. 7 references.

Investigation of the performance of a blowdown turbine installed in the exhaust system of a twelve-cylinder, liquid-cooled engine of 1,710- cu.in. displacement showed that the maximum turbine power occurred at a value of blade speed equal to about 0.4 of the mean jet velocity at the turbine-nozzle exit. The approximate maximum horsepower for the range of the investigation was 134 hp. at an average exhaust pressure of 14.4 in. mercury absolute when the engine operated at 2,000 r.p.m., an engine inlet-manifold pressure of 40 in. mercury absolute, and a fuel-air ratio of 0.085. The corresponding engine brake horsepower was 890 as compared with 927 hp. that the engine would have developed if the turbine were not in the system. Calculations of various engine systems showed that, at an altitude of 45,000 ft., a compound engine incorporating a blowdown turbine and a steady-flow turbine in series in the engine exhaust and geared to the engine crankshaft produced 23 per cent more power than a turbosupercharged engine. The blowdown-turbine compound engine produced more power than the steady-flow turbine compound engine at altitudes from sea level to about 31,000 ft. and lower specific fuel consumption at altitudes up to 9,000 ft. For low-altitude operation, the geared blowdown-turbine system gave approximately the same power and economy as the system incorporating a blowdown turbine and a steady-flow turbine in series designed for the best-power operation.

Dynamometer-Stand Investigation of the Muffler Used in the Demonstration of Light-Airplane Noise Reduction. K. R. Czarnecki and Don D. Davis, Jr. *U.S., N.A.C.A., Technical Note No. 1688*, October, 1948. 29 pp., illus., figs. 3 references.

An investigation of the attenuation characteristics of a muffler designed for the quiet-airplane demonstration tests showed that the muffler alone reduced the engine overall noise level by values ranging from almost 15 db. at 1,650 r.p.m. to approximately 10 db at 2,790 r.p.m. The addition of a long tail-pipe with a right-angle bend gave a further reduction of about 5 db. at some engine speeds. Further reductions in overall noise level of the engine appear to be possible only by quieting the intake and the engine-clatter noises. Back pressures were about one-third higher for the muffler installations than for the unmodified exhaust system at 2,790 r.p.m. and were lower at lower engine speeds. Some correlation between theory and experiment seems possible as to the existence and the location of cutoff frequencies and pass bands despite excessive interfering noises and the inaccuracy of instrument readings at low noise levels. Ground and flight tests checked fairly well.

Internal Combustion Engines. R. J. Bender. *Combined Intelligence Objectives Sub-Committee, Item No. 19 & 30, File No. 31-78*, July, 1945. 16 pp., diagrs. British Information Services, New York. $0.55.

Description of the Ring-Process (Ringverfahren) for the ignition of internal-combustion engines. The spark plug is replaced by an ignition liquid, such as butadioldiethyl ether or diethyldiglycol ether, which is introduced into the cylinder as a finely atomized spray at the proper moment of the combustion cycle. Bench and flight tests showed that the method was not unduly sensitive to timing and that it operated satisfactorily over a wide range of fuel-air mixtures. The process appeared to call for precise engine cooling. Conventional spark plugs were necessary for starting.

A Theoretical Investigation into the Porting of a Two-Cycle High Mean Effective Pressure Internal Combustion Engine. George Parker. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue, No. 34*, 1947, pp. 367–373, Discussion, pp. 373, 374, diagrs., figs. 6 references.

An Investigation of the Airbox Method of Measuring the Air Consumption of Internal Combustion Engines. L. J. Kastner. *Institution of Mechanical Engineers, Proceedings, Vol. 57, War Emergency Issue No. 34*, 1947, pp. 387–396, Discussion, pp. 396–404, diagrs., figs. 23 references.

Type Test of the Kinner R-440-3 Engine. W. D. Downs. *U.S., Army Air Forces, Technical Report No. 5040*, October 25, 1943. 31 pp., illus., figs.

Some Aspects of Petrol Injection Equipment Development. K. Brook and W. E. W. Nocolls. *Institution of Mechanical Engineers, Automobile Division, Proceedings, 1947-1948, Part I*, pp. 30–43, Discussion, pp. 43–50, diagrs., figs. 4 pp. of illus.

Piston Aero-Engines. Harry R. Ricardo. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 29*, 1947, pp. 193–197, illus., diagr.

Survey of Power Plant Installation Troubles. John W. Baird. *Shell Aviation News*, No. 123, September, 1948, pp. 17–19, figs. (Extended summary of a paper.)

ROCKET (4)

Sweat Cooling of Nozzle Surfaces Under High Thermal Stress. F. Meyer-Hartwig. (*Luftfahrtforschungsanstalt Hermann Göring, Braunschweig, ZWB/FB/1740*, December 1, 1940.) *U.S., Air Force, Translation No. F-TS-2067* (*ATI No. 22204*), September, 1948. 18 pp., illus., diagrs., fig.

Calculation of the amount of coolant required by jet exhaust nozzles fabricated from a porous material and cooled by forcing a coolant through the material into the high-temperature interior of the nozzles. Includes a discussion of the properties of sintered metals for this application.

Production (36)

Aircraft Manufacture in the Netherlands. James Hay Stevens. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, pp. 298–302, illus. The design, production, techniques, and assembly of the Fokker Promotor, a tail-boom, low-wing aircraft intended for air-taxi work.

The Life of Carbide-Tipped Turning Tools. F. F. P. Bisacre and G. H. Bisacre. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 35*, 1947, pp. 452–461, Discussion, pp. 461–469, diagrs., figs. 2 pp. illus.

Spun Glass Blankets for Press Stretching. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, p. 315, illus.

The use of a spun glass blanket 0.027 in. in thickness for the hot-forming of magnesium-alloy sheets at The Glenn L. Martin Company Baltimore plant eliminates the necessity of using grease, oil, graphite, or other lubricants and substantially reduces the time required for the stretch-forming operation.

Propellers (11)

Effect Caused by the Direction of Propeller Rotation on the Stability of an Airplane with Two Propellers. E. Petersohn. (*Sweden, Flygtekniska Försöksanstalten, Stockholm, FFA Rapport Nr. 7.*) *Sweden, Kungl. Flygforvaltningen* (*Royal Swedish Air Board, RSA B*), *Translation No. 1*, 1946. 17 pp., diagrs., figs. (In English.)

A wind-tunnel investigation to determine the effect of the slipstream on the pitching moment and on the longitudinal stability of two-engined aircraft with symmetrically rotating propellers. When the upper blades of the propellers rotated outward, the variation of the moment with changes in the propeller loading and the stability of the aircraft were greater than when the upper blades of the propellers rotated inward. This is attributed to the smaller downwash and the smaller variation of the downwash angle of attack in the former case. The change of downwash angle with the angle of attack usually diminishes the stability of an aircraft with rotating propellers to a greater extent than can be compensated for by the increase of dynamic pressure in the slipstream.

Calculation of the Effect of Thrust-Axis Inclination on Propeller Disk Loading and Comparison with Flight Measurements. A. W. Vogeley. *U.S., N.A.C.A., Technical Note No. 1721*, October, 1948. 17 pp., illus., figs. 2 references.

An analysis based on simple geometry gave results in good agreement with flight-test data and seemed adequate for predicting the primary effects of thrust-axis inclination in spite of the fact that interference effects were neglected. For a given propeller, the least complicated methods for reducing blade stresses arising from inclination appear to be a compromise thrust-axis setting and the restriction of the thrust-axis angle-of-attack range by the use of flaps.

Advantages Seen for Extruded Propellers. Walter H. Korff. *Aviation Week*, Vol. 49, No. 16, October 18, 1948, pp. 21, 22, 25, illus. Both two-bladed and three-bladed fixed-pitch propellers milled from extrusions and designed for the Ercoupe showed virtually constant speed operation at nearly their rated r.p.m. for climb and cruising speeds.

Influence du Souffle d'Une Hélice Sur les Caractéristiques Aérodynamiques d'Une Maquette Motorisée (Influence of Propeller Slipstream on the Aerodynamic Characteristics of a Powered Model). I, II, III. J. Kampé de Fériet and A. Fauquet. *France, Groupement Français pour le Développement des Recherches Aéronautiques, Note Technique Nos. 2, 4, 5*, March, May, September, 1939. 58; 58; 40 pp., illus., diagrs., figs. 2 references.

Whirl Test of an 11 Ft. 6 In. Hamilton Standard Hydromatic Propeller Blade Design 6259A-0, Hub Design 33D50. D. F. Hild. (Whirl Test No. 1545.) *U.S., Army Air Forces, Technical Report No. 4906*, April 16, 1943. 17 pp., illus., figs.

Type Test of Engineering and Research Corporation Propeller, Drawing No. 3081-2. W. T. Butt. (Whirl Test No. 1604.) *U.S., Army Air Forces, Technical Report No. 5028*. 23 pp., illus., figs.

Type Test of Thomson Industries Constant Speed Propeller for Use on the 0-435 Engine. Earle A. Vonderheid. (Whirl Test No. 2125.) *U.S., Army Air Forces, Technical Report No. 5582*. 41 pp., illus., figs.

Type Test of a Two Blade, 9 Ft. 0 In. Diameter Propeller, Consisting of Two Freedman-Burnham Corporation Resin Impregnated Maple Blades, Design No. 42K13717, Assembled in a Hamilton Standard, Counterweight Type, Constant Speed Hub, Design No. 2D30-229. Lyle H. Corsaw. (Whirl Test No. 1762.) *U.S., Army Air Forces, Technical Report No. 5123*, July 24, 1944. 11 pp., illus., figs.

Type Test of Engineering and Research Corporation Impregnated and Compressed Wood Blades, Design No. 3086A, Mounted in a Hamilton Standard 2B20 Hub. L. C. Gatewood. (Whirl Test No. 1634.) *U.S., Army Air Forces, Technical Report No. 5124*, July 25, 1944. 11 pp., figs.

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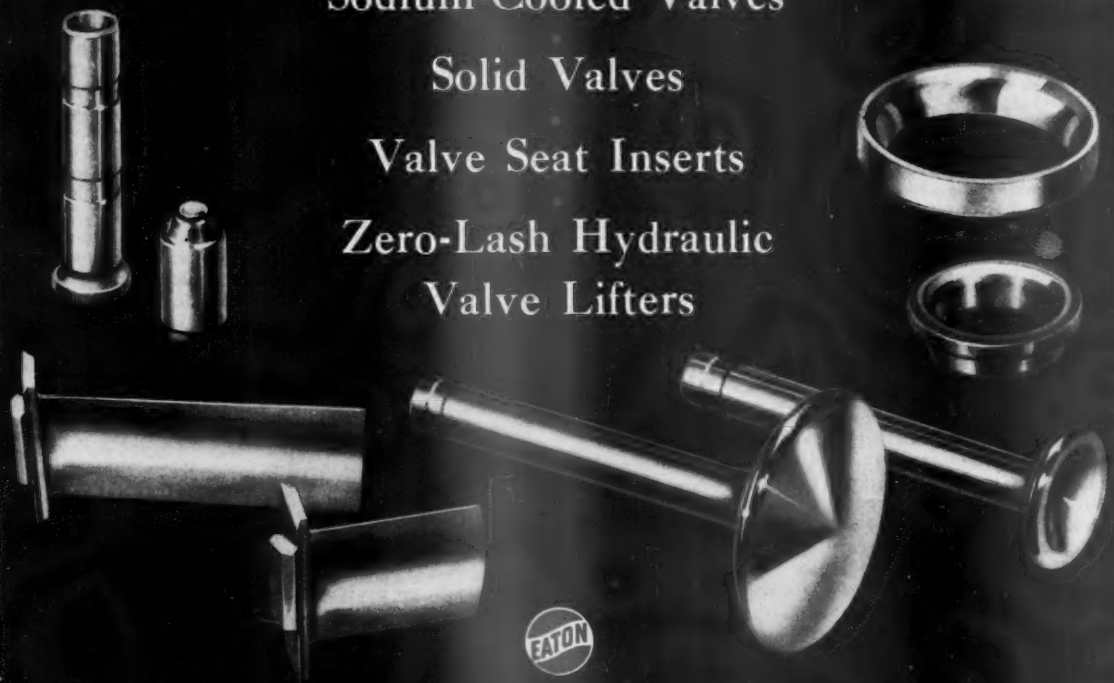

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Whirl Test of a Hamilton Standard Blower Spinner, Part No. 55400, on an 11 Ft. 3 In. Hydromatic Propeller. D. G. Hild. (Whirl Test No. 1552.) *U.S., Army Air Forces, Technical Report No. 4955,* June 28, 1943. 5 pp.

Type Test of a Two-Blade Propeller, Consisting of Two Engineering & Research Corporation Wood and Plastic Blades, Mounted in a Hamilton Standard Hub, on an R-985-AN-1 Engine. Lyle H. Corsaw. (Whirl Test No. 1642.) *U.S., Army Air Forces, Technical Report No. 5002,* August 26, 1948. 21 pp., illus., figs.

Whirl Test of an 11 Ft. 3 In. Rotol Hydraulic Controllable Pitch Propeller Consisting of Three Jablo Wood Blades of Design No. RA4065/J in a Type No. RS53 Hub. D. F. Hild. (Whirl Test No. 1600.) *U.S., Army Air Forces, Technical Report No. 5030,* October 15, 1943. 23 pp., illus., figs.

Engine Test of a 12 Ft. 2 In. Diameter Composite Propeller, Consisting of a Curtiss 4-Blade Hollow Steel C542S-714-1C2-12A Propeller Adapted to Use a Hamilton Standard Hydromatic 24E50 Dome Assembly. Lyle H. Corsaw. (Whirl Test No. 1751.) *U.S., Army Air Forces, Technical Report No. 5084,* February 12, 1944. 9 pp., illus.

Type Test of Propeller Spinner, Hamilton Standard Part No. 60086. P. M. Lasswell and Lyle Corsaw. (Whirl Test No. 1706.) *U.S., Army Air Forces, Technical Report No. 5039,* October 23, 1943. 7 pp., illus.

Whirl Test of a Laminated Process Propeller, Blade Design No. X42K16016, Hub Design No. 39G2767, for Use on an R-680-9 Engine. R. A. Shultz. (Whirl Test No. 1671.) *U.S., Army Air Forces, Technical Report No. 5076,* January 28, 1944. 10 pp., illus., figs.

Engine Test of Hydromatic Propeller Using Various Combinations of Barrel Block Shims. L. H. Corsaw. (Whirl Test No. 2019.) *U.S., Army Air Forces, Technical Report No. 5543,* January 13, 1947. 2 pp.

Electric Motor Test of the Gardner Propeller, Design No. 37W576. Earl A. Vonderheid. (Whirl Test No. 2164.) *U.S., Air Force, Technical Report No. 5541,* January 30, 1948. 9 pp., illus., figs.

Engine Test of Modified North American P-51B Spinner DWG. No. 104-44002 Assembled on a Hamilton Standard Four-11 Ft. Diameter, 24D50-J6523A-24 Propeller on a V-1650-3 Engine. L. H. Corsaw. (Whirl Test No. 1898.) *U.S., Army Air Forces, Technical Report No. 5542,* January 30, 1947. 6 pp., illus.

Type Test of an Airproducts Propeller Model A642-X12, for Use on the R-2800-22W Engine, Installed on the Navy F8F Airplane. D. A. Dickey. (Whirl Test No. 1992.) *U.S., Army Air Forces, Technical Report No. 5547,* February 10, 1947. 68 pp., illus., diagrs., figs.

Type Test of an 11 Ft. 7 In. Diameter Propeller Having Three American Propeller Corp. XH2891106 Blades. P. M. Lasswell. (Whirl Test No. 2094.) *U.S., Army Air Forces, Technical Report No. 5578,* April 29, 1947. 24 pp., figs.

100-Hour Endurance Test of the Thomson Industries Propeller on the O-435 Engine. (Whirl Test No. 2083.) *U.S., Army Air Forces, Technical Report No. 5577,* April 24, 1947. 9 pp., illus.

Type Test of Hamilton Standard Hydromatic 24D50-J6523A-24 Propeller, A Hamilton Standard 60086 Spinner and North American 105-44002, 102-44002, 102-44002-10 Spinners for Use on a P-51B Airplane Powered by a V-1650-3 Engine. C. M. Lasswell. (Whirl Test No. 1818.) *U.S., Air Force, Technical Note No. 5593,* 1947. 55 pp., illus., figs.

Calibration of Fixed Pitch 6-Way Wood Test Club Part No. X42N19275M. Ira R. Barr. (Whirl Test No. 2069.) *U.S., Army Air Forces, Technical Report No. 5610,* July 14, 1947. 10 pp., illus., figs.

Electric Motor Tests of Ground Adjustable Propeller, Hub Design No. 5406, Koppers Blade Model PA1-102. Earl A. Vonderheid. (Whirl Test No. 2140.) *U.S., Army Air Forces, Technical Report No. 5545,* February 3, 1947. 9 pp., illus., figs.

Whirl Test of the Canadian Car and Foundry Propeller Model P44E960 for Use on the O-425 Engine. Earl A. Vonderheid. (Whirl Test No. 2010.) *U.S., Air Force, Technical Report No. 5608,* July 14, 1947. 16 pp., illus., figs.

Electric Motor Whirl Test of a 12 Ft. Diameter Dual Rotation Aeroproducts Propeller for Use on the R-2800-16 Engine. E. K. Grimes. (Whirl Test No. 1830.) *U.S., Army Air Forces, Technical Report No. 5612,* July 14, 1948. 13 pp., illus., figs.

Electric Motor Whirl Test of a Curtiss C642S-B Propeller with a A. E. Smith SPA-9-200 Blades. A. E. Shaw. (Whirl Test No. 1963.) *U.S., Army Air Forces, Technical Report No. 5613,* July, 14, 1947. 11 pp., illus., figs.

Approval Test of Propeller Spinner, N.A.A. Part No. X101-944003. B. M. Lasswell and L. H. Corsaw. (Whirl Test No. 1683.) *U.S., Army Air Forces, Technical Report No. 5000,* August 25, 1943. 7 pp., illus.

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Electric Motor Test of Utility Fan Corporation Spinner No. 7-200 for P-61C Airplane. C. I. Valentine. (Whirl Test No. 2100.) *U.S., Army Air Forces, Technical Report No. 5614,* July 11, 1947. 2 pp., illus.

Type Test of a Hamilton Standard Propeller, Design No. 24E50-65-6507A-2, For Use on the P-47D Airplane Having an R-2800-21 Engine. P. M. Lasswell. (Whirl Test No. 1883.) *U.S., Army Air Forces, Technical Report No. 5537,* January 10, 1947. 27 pp., figs.

Whirl Test of the Zimmer-Thomson Constant Speed Propeller for Use on the O-425 Engine. (Whirl Test No. 2054.) *U.S., Army Air Forces, Technical Report No. 5549,* February 13, 1947. 7 pp., illus., figs.

Partial Type Test of X43K13099, 9 Ft. 0 In. Diameter Hydulignum Blades in a 2D30-227 Hub, for Use on a BT-13 Airplane. Ira R. Barr. (Whirl Test No. 1810.) *U.S., Army Air Forces, Technical Report No. 5548,* February 13, 1947. 8 pp., illus., diagr.

Electric Motor Whirl Test of Curtiss C532S-D Propeller with American Propeller Corp. Design C2761000 Blades. A. E. Shaw. (Whirl Test No. 2035.) *U.S., Army Air Forces, Technical Report No. 5550,* February 13, 1947. 9 pp., figs.

Whirl Test of Metal Rotor Blade Incorporating Boundary Layer Slot. Raymond N. Gattfried. (Whirl Test No. 2057.) *U.S., Army Air Forces, Technical Report No. 5552,* February 24, 1947. 19 pp., illus., diagrs., figs.

Electric Motor Tests of the Thomson Industries Two-Blade, 8 Ft. 6 In. Diameter Propeller, Model A-200-OD. Earl A. Vonderheid. (Whirl Test No. 2085.) *U.S., Army Air Forces, Technical Report No. 5572,* April 18, 1947. 10 pp., illus., figs.

Type Test of Montgomery Propeller Spinner with Attached Cooling Fan. P. M. Lasswell. (Whirl Test No. 1781.) *U.S., Army Air Forces, Technical Report No. 5538,* January 15, 1947. 6 pp., illus.

Alternating Stresses in Wood Propeller Blade Retaining Screws. C. R. Gaskell. (Whirl Test No. 2027.) *U.S., Army Air Forces, Technical Report No. 5611,* July 14, 1947. 12 pp., figs.

Type Test of Erco 8 Ft. 6 In. Propeller Blades Design 3174-10, In 2B20 Hub. (Whirl Test No. 1812.) *U.S., Army Air Forces, Technical Report No. 5609,* July 16, 1947. 12 pp.; illus., diagr., figs.

Type Test of Several Spinners for Hamilton Standard 24D50 Propellers on P-51 Airplanes. B. Chasman. (Whirl Test No. 2091.) *U.S., Army Air Forces, Technical Report No. 5607,* July 9, 1947. 9 pp., illus.

A Method for Evaluating Propeller Ice Preventing and/or Removing Devices. D. F. Matson and R. C. Treseder. *U.S., Army Air Forces, Technical Report No. 5037,* October 23, 1943. 28 pp., illus., diagrs.

Reference Literature (47)

HISTORY

The Battle of Britain Through German Eyes. *The Aeroplane,* Vol. 75, No. 1947, October 1, 1948, pp. 443, 444, illus.

Rotating Wing Aircraft (34)

Effect of Wind Velocity on Performance of Helicopter Rotors as Investigated with the Langley Helicopter Apparatus. Paul J. Carpenter. *U.S., N.A.C.A., Technical Note No. 1698,* October, 1948. 26 pp., illus., figs. 4 references.

Two representative helicopter rotors with widely different characteristics were investigated with the Langley helicopter apparatus to determine the effect of wind velocity on the hovering performance. The results show an appreciable decrease in power required for a given thrust as the wind velocity increases. Comparisons of the results with theoretical results show good agree-

ment. A description of the Langley helicopter apparatus and its instrumentation is also included.

New Way to Gage Hovering Performance. Paul H. Stanley. *Aviation Week*, Vol. 49, No. 17, October 25, 1948, pp. 21, 22, figs. 2 references.

By assuming that, for a helicopter blade in hovering flight, a virtual plane of symmetry may be located at the radial centroid determined by the elements of blade chord multiplied by the rotational velocity squared, a correction factor is plotted for the blade-root and tip losses. This correction factor improves the correspondence of calculated lift with data obtained in flight tests.

Contribution to the Problem of Helicopter Stability. Kurt Hohenemser. *American Helicopter*, Vol. 12, No. 11, October, 1948, pp. 18–20, figs. (Extended summary of a paper.)

An Outline of Helicopter Design. II. John C. Vogtle. *American Helicopter*, Vol. 12, No. 11, October, 1948, pp. 12, 13, 22, 23, diagrs. Engineering studies of the rotor-hub linkage, controls, and drive system; the kinematics of the control system and the procedure for laying out the kinematics of the swash plate.

Kaman K-190 Servo Flap Rotor Control. M. Berry. *American Helicopter*, Vol. 12, No. 10, September, 1948, pp. 6, 7, 18–20, illus.

Tie-Rod Transmission. Maurice F. Allward. *Flight*, Vol. 54, No. 2077, October 14, 1948, p. 458, fig.

One worm gear on the drive shaft meshes with two worm discs, each of which transmits power to a rotor by twelve high-tensile steel rods. This transmission, used in the Landgraf H-2, is 30 per cent lighter than the conventional torque-tube bevel-gear installation.

Calibration and Destructive Whirl Test of a Rotor Blade for the YG-1C Autogiro. A. H. Zonars. (Whirl Test No. 1476.) *U.S., Army Air Forces, Technical Report No. 5147*, September 16, 1944. 17 pp., illus., figs.

Spraying and Dusting Equipment for the (Bell) 47-D. Roger W. Roth. *American Helicopter*, Vol. 12, No. 11, October, 1948, pp. 14, 23, 24, diagrs.

The Hoppi-Copter. *Flight*, Vol. 54, No. 2077, October 14, 1948, pp. 466, 467, illus. The power plant, simplified control system, and the flight performance displayed by the Pentecost Hoppi-Copter 102 during a demonstration in England.

An Aerial Motorcycle (The Pentecost Hoppi-Copter Model 102). *The Aeroplane*, Vol. 75, No. 1949, October 15, 1948, p. 506, illus.

Sciences, General (33)

PHYSICS

The Electron Microscope. Edward A. Smith. *Aeronautics*, Vol. 19, No. 5, October, 1948, pp. 46, 47, diagrs.

A Technique for High Rotational Speeds. D. G. Marshall, P. B. Moon, J. E. S. Robinson, and J. T. Stringer. *Journal of Scientific Instruments*, Vol. 25, No. 10, October, 1948, pp. 348–351, diagrs., fig. 1 reference.

Stress Analysis & Structures (7)

Shear Lag in Axially Loaded Panels. Paul Kuhn and James P. Peterson. *U.S., N.A.C.A., Technical Note No. 1728*, October, 1948. 24 pp., figs. 9 references.

The calculation of shear-lag effects in axially loaded panels by means of the "substitute single-stringer panel" is simplified by an empirical expression for the width of the substitute panel which eliminates the need for successive approximations. For simple types of single-stronger panels, a theory not dependent on the assumption of infinite transverse stiffness is developed which can be used to estimate the effect of transverse stiffness on the stresses in practical panels. Strain measurements on five panels indicate that the theory should be adequate for design purposes and that the effect of transverse stiffness may be appreciable.

Buckling of a Long Square Tube in Torsion and Compression. Bernard Budiansky, Manuel Stein, and Arthur C. Gilbert. *U.S., N.A.C.A., Technical Note No. 1751*, November, 1948. 17 pp., figs. 2 references.

The buckling of an infinitely long square tube under combined torsion and compression is investigated by means of an exact energy method utilizing Lagrangian multipliers. An interaction curve is obtained from which it is possible to determine the amount of loading, in either torsion or compression, which is required to produce buckling when a given amount of one of the loadings is present.

The Stresses in Closed Cylindrical Vessels. H. D. Conway. *Aircraft Engineering*, Vol. 20, No. 236, October, 1948, pp. 297, 314, figs.

Expressions are derived for the maximum bending moment and shearing force in cylindrical vessels closed at both ends by flat plates or hemispheric shells and subjected to gas pressure. The expressions are plotted as graphs, and their use is illustrated by numerical examples.

De Arbeid, die de Luchtkrachten per Tijdseenheid op een Trillenden Vleugel Verrichten en de Kritische Trillingsvormen van een Vleugel (The Energy Supplied per Unit of Time by the Aerodynamic Force on an Oscillating Wing and the Critical Modes of Oscillation of a Wing). J. H. Greidanus. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport No. V. 1237*, November 8, 1940. 19 pp. 4 references. (English summary.)

Reliability of the Drop Weight Reduction Method for Simulating Wing Lift Effect in Landing Gear Drop Tests. W. K. G. Floor. *Netherlands Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport Nr. S.340*, July 30, 1948. 34 pp., figs., tables. (In English.)

A mathematical analysis of a simplified model of a landing gear, in which the deformation of the tire and the influences of friction are neglected, showed that in the free drop the maximal load is only slightly smaller than in the air-borne drop. This result was confirmed by the numerical evaluation of drops with an actual landing gear in which the deformation was accounted for. Therefore, the results that are obtained in free-drop tests in which the influence of wing lift is simulated by reducing the drop weight will be slightly unconservative. The errors, however, are sufficiently small to be neglected.

De Standtrilling van den Vleugel van Vrijeragende Ééndekkers (Ground Vibration Testing of the Wing of a Cantilever Monoplane). J. H. Greidanus. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport No. V. 1234*, 1940. 28 pp. 3 references.

De Berekening van de Kritische Snelheid voor Onstabiele Trillingen van Vliegtuigvleugels (The Calculation of the Critical Flutter Speed of Airplane Wings). J. H. Greidanus. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport No.*

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V. 1252 (*Verslagen en Verhandelingen, Deel No. 10*), 1941. 92 pp., figs. 23 references.

Voorkoming van Onstabiele Trillingen van Deelen van Vliegtuigen Tijdens de Vlucht (Prevention of Unstable Vibrations of Parts of an Airplane During Flight). J. H. Greidanus. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport No. V. 1146*, January, 1940. 125 pp., figs. 44 references.

AMC Gets Unique Recording Scale for Aircraft. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 20, October 15, 1948, pp. 11, 12, illus.

Dives Vary Craft Temperatures. *Aviation Week*, Vol. 49, No. 16, October 18, 1948, pp. 25, 26. 1 reference. Summary of N.A.C.A. tests to determine thermal gradients induced in aircraft structures by change in ambient temperature and air friction during high-speed dives and the accompanying thermal stresses.

Thermodynamics (18)

Relation Between Temperature and Velocity Fields of a Gaseous Torch. V. A Schwab. (*Zhurnal Tekhnicheskoi Fiziki* (U.S.S.R.), Vol. 2, No. 5, 1941, pp. 431–442.) *Cornell Aeronautical Laboratory, Translation*, 1948. 19 pp., diagrs., figs.

An analysis of the burning of a jet of gas in an atmosphere containing oxygen. The identity of the formulas for the velocity field of the jet, the field of the concentration of the gas, and the temperature field of the jet show the similarity that exists among these aspects of the combustion process. The jet is divided by two distinct zones of burning into three regions, the first of which contains the products of combustion and a considerable quantity of unburnt gas. The third zone contains the products of combustion which diffuse in the air. The length of this zone of diffusion burning depends fundamentally upon the air-gas ratio of the gas issuing from the combustion orifice. As the mixture becomes richer, the diffusion zone lengthens to its limiting value, which is that of purely diffused burning of pure gas. As the mixture is made leaner, the length of the diffusion burning zone also depends on the relative oxygen content of the atmosphere surrounding the jet. The greater this content, the smaller is the length of the zone.

On the Addition of Heat to a Gas Flowing in a Pipe at Subsonic Speed. Joseph V. Foa and George Rudinger. *Cornell Aeronautical Laboratory, Report No. HF-534-A-1*, July 8, 1948. 53 pp., figs. 22 references.

The addition of heat modifies the state and flow conditions not only downstream but also upstream of the region of heat addition in a manner that depends on the boundary conditions. The modifications are often greater upstream than downstream. The conditions upstream of the region of heat addition, therefore, should not be taken as the initial conditions (before heating), and equations heretofore derived by other investigators should be interpreted as relating conditions upstream and downstream of the heating region but not those before and after the addition of heat. The static temperature of the gas is found not to decrease when heat is added at an initial Mach Number greater than the reciprocal of the square root of the ratio of specific heats. The amount of heat that can be added is not limited by the attainment of $M = 1.0$. The effect that the addition of heat may have on the mass flow through the pipe depends exclusively on the boundary conditions.

An Investigation of Aircraft Heaters. XXIX—Comparison of Several Methods of Calculating Heat Losses from Airfoils. L. M. K. Boelter, L. M. Grossman, R. C. Martinelli, and E. H. Morrin. *U.S., N.A.C.A., Technical Note No. 1453*, October, 1948. 70 pp., figs. 27 references.

A critical comparison and a summary of the methods used by Allen and Look, Fric, and McCullough, Martinelli and others, and Squire for calculating the unit thermal conductance on the outer surface of a heated wing with both laminar and turbulent boundary layers. Another method of analysis is proposed which gives more emphasis to the effect of the pressure gradient on the laminar heat transfer than the other methods. It is based on relations that hold true for any boundary layer regardless of the shape of the section, and it does not have recourse to the Blasius flat-plate solution. Unit thermal conductances in the laminar and turbulent régimes are computed for a Joukowski profile in order to compare the different methods, and the results are found to be in good agreement. The method of applying the equations for heat transfer from airfoil surfaces to a propeller shape is illustrated. The appendix includes a discussion of the basic postulates that underlie boundary-layer theory and the solution of the boundary layer differential and momentum equations.

Water-Borne Aircraft (21)

Spray Characteristics of Four Flying-Boat Hulls as Affected by Length-Beam Ratio. William W. Hodges and David R. Woodward. *U.S., N.A.C.A., Technical Note No. 1726*, October, 1948. 49 pp., illus., diagr., figs. 5 references.

Comparative data on the spray characteristics in smooth water of four related models having length-beam ratios of 6, 9, 12, and 15. At the heavier gross loads, all models encountered spray of about the same intensity. The models having the higher length-beam ratios were subjected to more severe spray on the tail surfaces. The spray characteristics of the models agree well with the spray criterion as set forth in *N.A.C.A. A.R.R. No. 3K08*.

On the Pressure Distribution for a Wedge Penetrating a Fluid Surface. John D. Pierson. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 167*, 1948. 33 pp., figs. 4 references. $1.00.

An elaboration and extension of the theories originated by H. Wagner for estimates of the pressures acting on a Vee surface, the keel of which penetrates the water surface while the chine remain above it. Mathematical analysis and test data show Wagner's spray-root analysis and expanding laminar pressure analysis to be compatible in that they yield practically identical peak pressures. The spray-root analysis gives more detailed, and presumably more correct, pressure distribution at the edge of the wetted area. The results of the spray-root analysis in this region differ from the pressures due to expanding plate theory by extending the pressure area outboard of the stagnation point and by providing somewhat less abrupt drop of pressure in this direction. Test pressures obtained on a 20° deadrise planing surface at 6° trim are in close agreement with the predictions of the theory for the effective deadrise of 22.5°. The theory may be expected to predict bottom pressures at least up to 22.5° deadrise and probably above that with reasonable accuracy.

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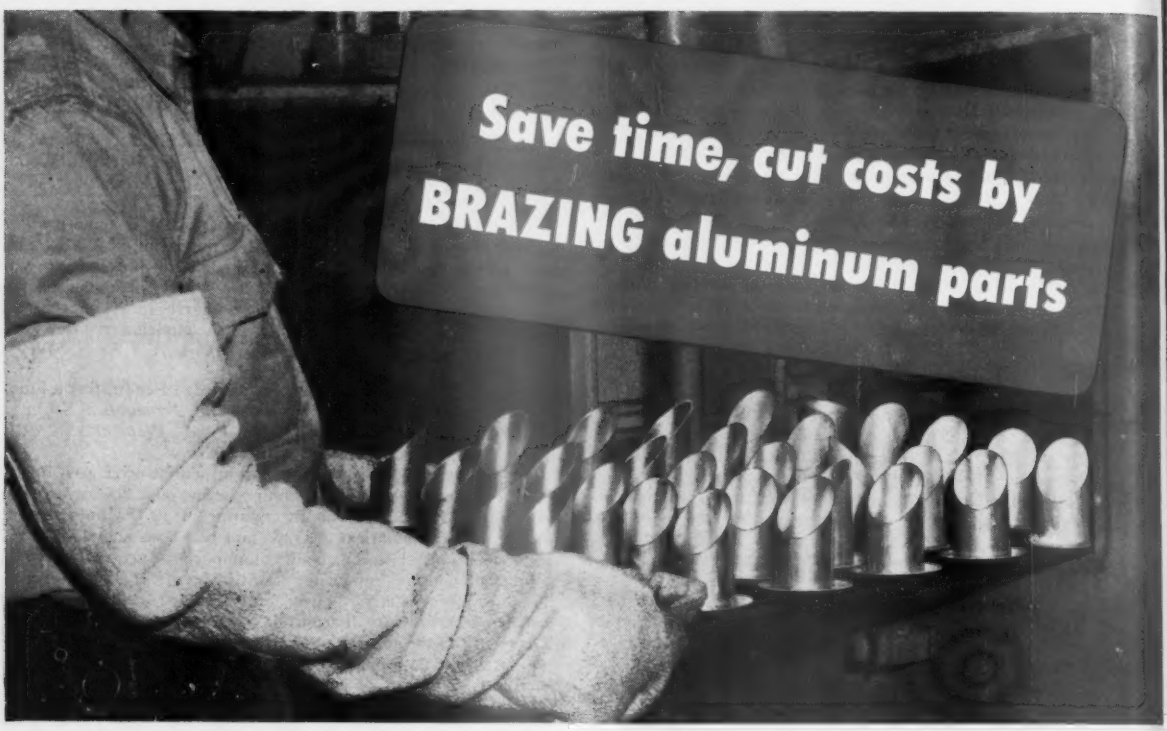

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Wave Contours in the Wake of a 20-Degree Deadrise Planing Surface. B. V. Korvin-Kroukovsky, Daniel Savitsky, and William F. Lehman. *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 168*, 1948. 51 pp., diagrs., figs. 6 references. $1.60.

Tests were made at the Experimental Towing Tank of Stevens Institute of Technology to determine the shape of the wave contours in the wake of a 20° deadrise planing surface under test conditions resembling the two-step planing condition of a seaplane. The longitudinal contour through the wake along the planing-surface centerline indicates a consistent variation with trim, speed, and aspect ratio and may be used to determine the afterbody wetted area. The data of this report and data to be obtained from tests of models with other deadrise angles are expected to provide a basis from which to develop an empirical means for defining this longitudinal contour for various planing conditions. The roach in the wake is most severely affected by changes in planing surface trim. It increases with increasing trim angle. The width between wave crests in any transverse section through the wake is such as not to interfere with afterbody bottoms of conventional design. The profiles in transverse planes through the the wake are such that the area of trough below level water is always larger than the area of water raised above the level water.

Wind Tunnels (17)

Practical Aspects of Cascade Wind Tunnel Research. K. W. Todd. *Institution of Mechanical Engineers, Proceedings, Vol. 157, War Emergency Issue No. 36*, 1947, pp. 482–490, Discussion, pp. 491–497, diagrs., figs., 6 pp. of illus. 9 references.

A discussion of the variables that must be accommodated in the design of high-speed sonic and subsonic wind tunnels for the testing of turbine or compressor blade cascades in two-dimensional flow and the quantities that must be measured, the necessary instrumentation, methods of taking the data and its interpretation, and the control system used to operate the tunnel.

Viscosity Effects in Wind Tunnel No. 2. S. A. Schaaf. *University of California, Department of Engineering, Engineering Research Projects (Fluid Flow and Heat Transfer at Low Pressures and Temperatures), Report No. HE-150-16*, August 6, 1947. 5 pp., fig.

An adaptation of the Pohlhausen approximate method for calculating the flows resulting from various nozzle shapes. The amount of calculation involved in the solution of the equations that are obtained would be unduly large in comparison with the limited application of the results because of the extreme simplifying assumptions that have been made. A closer approximation might be obtained by a cylindrically symmetrical theory in which the actual rectangular tunnel cross section would be replaced by a circle of equal area.

Flow Visualization at Low Pressures. R. A. Evans. *University of California, Department of Engineering, Engineering Research Projects (Fluid Flow and Heat Transfer at Low Pressures and Temperatures), Report No. HE-150-25*, September 16, 1947. 9 pp., diagrs. 6 references.

An investigation of the possibility of measuring or indicating the density changes in a wind-tunnel test section at low pressures by visualization methods that utilize absorption by gases or vapors of certain wave lengths or by the radiation emission of the gas. Absorption by mercury vapor of 2,537 Å. radiation is considered practical, but interpretation of results would be difficult. Absorption by ozone of 2,537Å. is also a possibility, and a sample calculation using this method is included. The major problem it presents, however, is the production of suitably high concentrations of ozone for the wind-tunnel required flow rates. If a suitable source of radiation could be developed, oxygen might be used to absorb wave lengths around 1,450 Å. Excitation of observable radiations from nitrogen and oxygen also might be used in place of the absorption technique.

Theory of Minimum Response Time for Vacuum Gages. S. A. Schaaf. *University of California, Department of Engineering, Engineering Research Projects (Fluid Flow and Heat Transfer at Low Pressures and Temperatures), Report No. HE-150-21*, August 15, 1947. 4 pp., fig. 2 references.

A New Device for Determining Wing Profile Drag by the Pitot Transverse Method. B. Reistad. (*Sweden, Flygtekniska Försöksanstalten, Stockholm, FFA Rapport Nr. 8.*) *Sweden, Kungl. Flygförvaltningen (Royal Swedish Air Board, SRAB), Translation No. 2*, 1948. 10 pp., diagrs., figs. (In English.)

A device for determining the wing profile drag on airfoil models by the momentum method with an integrating transversing pitot tube. Sample test measurements are used to estimate the error of the instrument. The value obtained for the difference between the total heat in the undisturbed flow and the mean value of the total heat in the wake was 2 per cent too low. This error was caused by the retardation of the motor at the ends of the traverse and was eliminated by incorporating a flywheel in the device.

New Supersonic Tunnel Largest Operating (N.A.C.A. Ames Aeronautical Laboratory). *Aviation Week*, Vol. 49, No. 16, October 18, 1948, p. 31, illus., diagr.

Qualification de la Turbulence en Souffierie par le Nombre de Reynolds Critique d'une Sphère ou d'un Cylindre (Wind-Tunnel Turbulence as Determined by the Critical Reynolds Number of a Sphere or a Cylinder). P. Guienne. **Introduction.** J. Kampé de Fériet. *France, Groupement Français pour le Développement des Recherches Aéronautiques, Rapport Technique No. 3*, 1940. 88 pp., illus , figs. 26 references.

Application of Servo Systems to Aircraft

(*Continued from page 43*)

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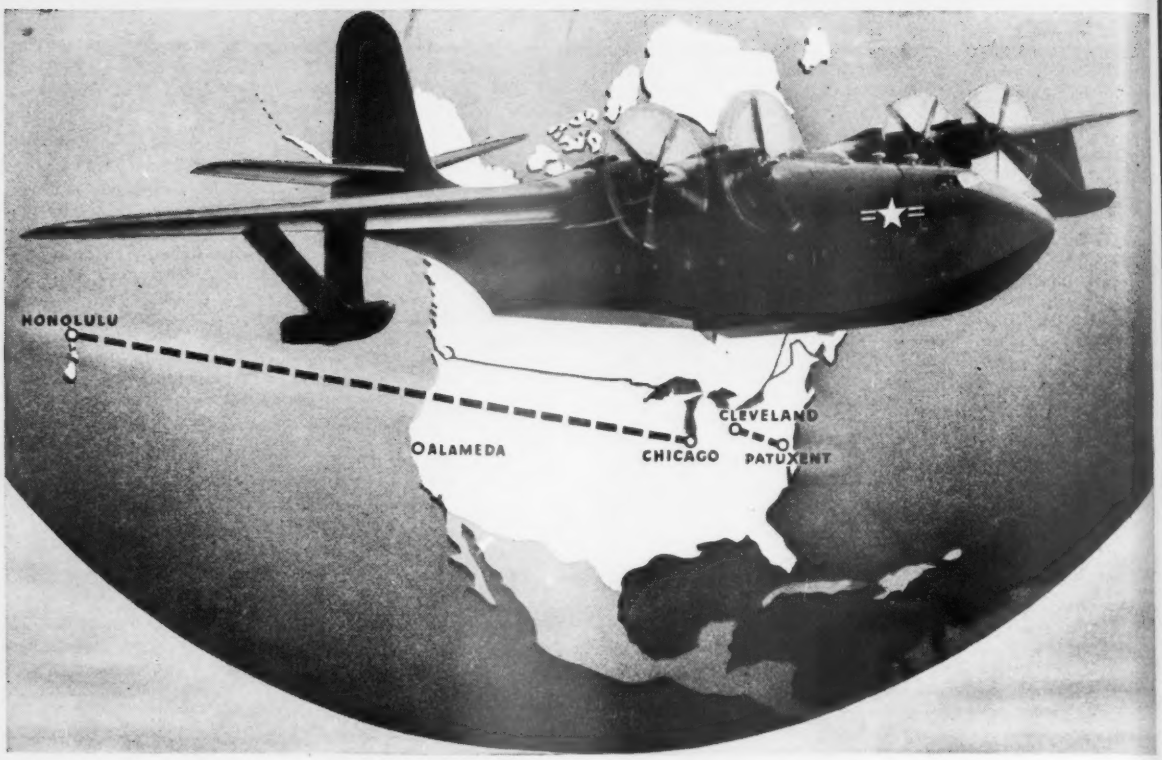

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Books

Supercharging the Internal Combustion Engine

By E. T. Vincent. New York, McGraw-Hill Book Co., Inc., 1948. 315 pp., illus., diagrs. $5.00.

As the author points out in his preface, his intention has been to provide in one package adequate explanation of the work of a great many people in this field for the benefit of persons who are not directly connected with the theory or development of superchargers. About two-thirds of the resulting book are devoted to various aspects of centrifugal and axial compressors themselves—namely, their principles, the calculation of their ideal performance, their testing, and the various mechanical means used to apply them to reciprocating engines. In addition, about one-third of the book is devoted to the theory of the Otto and Diesel engine cycles and the calculation of the performance of these types of engines when supercharged. As is customary in books of this kind, the book opens with a refresher chapter on elementary thermodynamic principles.

The author has successfully achieved his stated objective and is to be commended for his painstaking effort. This effort is particularly obvious in the minute step-by-step algebraic and arithmetical detail, which he never shirks from in presenting the explanation of fundamental principles of compressors, and in the calculation of ideal performance of compressors and of turbosuperchargers as well as of engine cycles. Such a degree of detailed explanation is seldom found in books of this kind, and he who wants answers will find most of them without overworking his imagination. This honest effort makes it unkind for this reviewer to be critical, yet certain things should be said, both for the protection of a certain class of student and particularly for the protection of the would-be designer.

The student should not be misled, by all this conscientious detail, into thinking that this is a highly complicated subject insofar as basic principles and the calculation of ideal performance are concerned. On the contrary, the ideal performance and also the performance with assumed but realistic overall efficiencies is usually easily calculated by just a handful of beautifully simple, straightforward relationships that apply alike to the axial and to the centrifugal compressor. Perhaps the most important of these relationships is the simple application of the Euler equation in separating the ideal temperature or enthalpy rise in the rotor (either axial or centrifugal of any assumed impeller blade shape) from the corresponding rise in the stator. This relationship (not presented in the subject book in the simple form I refer to)—when taken together with the well-known isentropic relations between temperature ratio, pressure ratio, and density ratio—places in the hands of the student or preliminary designer all the tools he needs to arrive at ideal performance and idealized shapes and dimensions of blades and passages. With further incorporation of any assumed overall efficiency values, he can also approximate actual performance provided his overall efficiency assumptions are correctly chosen, but actual shapes and dimensions with correct values of their corresponding efficiencies are another matter. A reference work pertinent to the above is an A.S.M.E. Paper by Moss, Smith, and Foote, not included in the bibliography of the book.

At variance with the detail used in presentation of principles and of calculations of ideal performance are the comments on *design* of compressor components so as to achieve good efficiencies. Here, the subject really *is* complex, but in this field the book suddenly becomes unduly simplified, without giving the uninitiated reader fair warning that he is barely touching on a field that is subject to numerous ramifications of approach and enormous variations in shape. For example, contrary to instructions of the book, few designers of the past decade actually increase the area of a centrifugal impeller passage, and the area of these impellers is usually held constant or actually converged by many designers, depending upon the pressure ratios sought and the tip speeds to which they resort in order to achieve them. Again, the slope of the impeller passage in a plane through the axis, which the book indicates to be from 10° to 15°, applies, as does the expanding passage mentioned in the previous sentence, to an old impeller that the earliest manufacturer standardized on for a period about 15 years. Impeller slopes and curvatures have extremely wide variations, depending on the velocity of through flow in relation to the speed of rotation, and they may slope as much as 60° from the vertical or they may slope not at all nor have an intermediate slope.

Further, with regard to the diffusers of centrifugal compressors, "overlapping" of the vanes, cited as essential, is not necessarily required. Static pressure tests taken in research in this field have long ago indicated that at least half, if not considerably more, of the pressure rise taking place in the diffuser occurs before the air reaches the throat or the point at which the so-called "overlapping" of the vanes occurs. Some diffusers, notably the old Rolls Royce Merlin XX, were extremely good as to their performance and had no overlap at all. Although the exact truth is substantially more complicated, a first approximation is that, with thin diffuser vanes of constant thickness, points of equal static pressure across the early portion of a diffuser passage lie more nearly on concentric circles than on lines at right angles to the passage centerline; and, with this conception, it may be demonstrated that the most effective diffuser action on the air begins immediately as the air crosses a circle drawn through all the leading vane tips.

Features such as these form a part of the research results through which efficiency, capacity, or pressure ratio performance of centrifugal impellers have gradually been increased over the years. It is a subject that is somewhat competitive and, therefore, has never been made available in one spot. But some of this information is provided in detail in certain items of the book's bibliography.

The chapter on principles and calculation of performance of axial compressors should include one of the many forms of equation for centrifugal effect on radial temperature or pressure gradients in a whirling ring of air. It should enlarge on the several

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widely differing types of velocity diagrams used other than the free vortex type discussed, indicating the effect of centrifugal forces on velocities and outlining the advantages and disadvantages of such other diagrams used with relation to limitations of capacity Mach number, number of stages required, and efficiency.

The author has comprehensively and correctly covered the requirements and the technical phases of the testing of centrifugal compressors, again presenting the subject in his commendable high degree of detail. However, it should be pointed out that, early in World War II, the principal aircraft-engine manufacturers and supercharger manufacturers combined forces through the medium of the N.A.C.A. Subcommittee on Supercharger Compressors to issue a standard procedure for testing. Their purpose was to provide the simplest possible requirement for equipment, instrumentation, and test procedure which would involve the minimum of investment and time and yet provide reliable comparability between the tests of various investigators insofar as determining overall performance of any given centrifugal compressor design is concerned. It would be well if this procedure were briefly discussed in the book and also incorporated in the bibliography.

KENNETH CAMPBELL
Manager, Research Division
Wright Aeronautical Corporation

Advances in Applied Mechanics

Vol. 1. Edited by Richard von Mises and Theodore von Kármán. New York, Academic Press, Inc., 1948. 293 pp., diagrs. $6.80.

The research-minded engineer finds himself today overwhelmed by new methods, theories, and mathematical aids and by the great variety of specialized fields. In order to follow, in general, the trends in science, he must read a great number of the diversified papers published. *Advances in Applied Mechanics*, the first of many volumes in preparation, is a collection of synopses on a variety of modern mechanical topics, that enable the reader at least to keep informed on what has been accomplished in certain far distant fields without going into specialized details.

While the topics collected in the book are not directly related to each other, one knows that as research in mechanics advances and expands more relation and interconnection between unrelated topics will take place.

Six sections are included in the present volume. The first, "Recent Advances in the Mechanics of Boundary Flow," by Dr. H. L. Dryden, is an important review for the aeronautical engineer. It collects the knowledge of laminar flow in boundary layers up to the year 1938 with an extensive and excellently chosen bibliography. The topic is then developed

more in detail, including a discussion of the pressure gradient and effects of compressibility. A complete, separate bibliography on stability of laminar boundary-layer flow and transition concludes this topic.

"Boundary Layer Suction" and "Turbulent Flow in Boundary Layers" are two additional subjects treated in this section. Dr. Dryden's method of approach and his painstaking collection of references is done masterfully. His style is easy to follow—in short, it's excellent reading.

The second section is contributed by Prof. N. Minorsky and deals with nonlinear mechanics. Before discussing the subject, one welcomes the opportunity to pay tribute to Professor Minorsky, who, only because of his modesty, is not more widely known to the aeronautical profession. He is the first to publish a comprehensive, useful, and practical theory of automatic controls of bodies with inertia. His theory, formulated some 30 years ago, is the basis of all modern automatic pilots and controls of guided missiles.

Nonlinear mechanics are encountered in flutter problems, automatic control, and vibration phenomena. Early in the nineteenth century eminent mathematicians came across nonlinear problems such as vibration problems with constantly varying masses. In some cases they succeeded in finding at least qualitative solutions that were based on linearization made possible by the assumption of small motions. For phenomena encountered in certain oscillating electrical circuits and aerodynamics, this method is not adequate.

Professor Minorsky treats his subject by introducing the reader to topology, which he illustrates graphically so that the reader becomes easily acquainted with expressions such as vortex point, saddle point, focal point, and nodal point. He proceeds to nonlinear conservative systems and equilibrium limits cycles and gives a good insight to the theories of Poincaré, Bendixson, and others. The reader gets, so to speak, a bird's-eye view of the totality of all possible motions that may occur in a dynamic system under the most varied conditions.

The rest of the section is devoted to analytical methods and approximations of higher order, and, finally, the subject of subharmonics and parametric excitations is dealt with.

Professor Minorsky's conciseness is remarkable. The 60 pages of his contribution are packed with exciting mathematical explanations, easily grasped by the practicing engineer. He opens his section with a quotation from Poincaré:

> "What makes these periodic solutions so valuable is the fact that they are, so to speak, the only breach through which we can penetrate a realm heretofore deemed inaccessible."

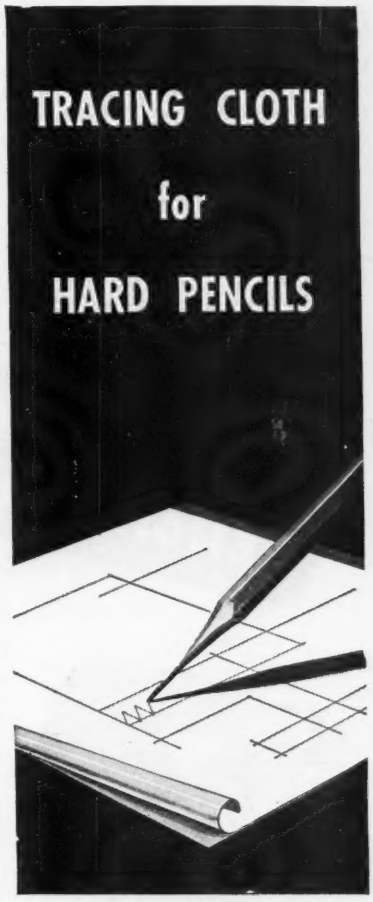
One can say that Professor Minorsky exemplifies the deep thought of this quotation.

The third and fourth sections are contributions from Holland written in the sad occupational years of 1940–1946. The collection of structural papers by C. B. Biezeno of the Technical Institute at Delft deals with elastic stability and, while original, they are mostly extensions, proofs, and refinements of work initiated in this country by Timoshenko, von Kármán, and Shanley. It is astonishing that during the occupation of Holland people like Dr. Biezeno could forget the physical and mental discomforts and produce such a creditable array of highly valuable papers.

The fourth section, entitled "A Mathematical Model Illustrating the Theory of Turbulence," was contributed by another Hollander, Prof. J. M. Burger. Logically, this paper should be put after Dr. Dryden's material, since it deals with statistical analysis and statistical mechanics pertaining to the problem of turbulent fluid motion.

Editorial comments on the relationship between the work of Dr. Dryden and that of Professor Burger would have been a valuable addition. Sections three and four, while technically interesting and beyond reproach, would have been much more readable if the editors had taken the time and care to anglicize some of the foreign expressions and literal translations, which are hard to understand except by those who are proficient in one or more foreign languages. For example, on page 149 one finds, "an alternating tension of such high frequency (1 M.Hz)," etc. In the American manner of speaking this should read, "an alternating voltage of a frequency of one megacycle." A few paragraphs later: "This magnified tension controls an electron-ray tube." This should read, "This amplified voltage controls a cathode-ray tube." Again, on page 151 the word "Eigenwert" appears. Surely there is an equivalent in English for it, such as "characteristic value." On the other hand, the references are treated excellently. Besides the original titles in Dutch, their correct translations in English are given. This system should have been adopted throughout the whole book wherever foreign references appear.

The fifth section is handled by Hilda Geiringer, of Wheaton College, and is entitled, "On Numerical Methods in Wave Interaction Problems." In this report a discussion of the hydrodynamic shock problem is given with the addition of a practical computational procedure. Of particular interest is the procedure for finding a continuous solution by taking the viscosity of the system into account. While the methods described in this section require a good knowledge of mathematics, they can be followed without much difficulty by the practicing engineer. The methods are applicable to one-, two-, and three-dimensional problems.



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The last section, written by one of the editors, Richard von Mises, and by M. Schiffer, of Harvard University, entitled "On Bergman's Integration Method in Two-Dimensional Compressible Fluid Flow," is an extensior and application of Bergman's method of using the theory of analytical functions in problems of partial differential equations of the elliptic type. This last paper requires a great deal of mathematical knowledge, but any graduate engineer who has had a review of some of the peculiar types of differential equations should be able to follow it profitably. An excellent bibliography finishes the section.

It is hoped that the editors will continue to collect such valuable papers and abridge them as extensive digests. Such collections are especially useful in places where access to specialized libraries is not available.

DR. STEPHEN J. ZAND
Vice-President in Charge of Engineering
Lord Manufacturing Company

Heat Conduction

By L. R. Ingersoll, O. J. Zobel, and A. C. Ingersoll. New York, McGraw-Hill Book Co., Inc., 1948. 278 pp., diagrs. $4.00.

To the well-known team of Ingersoll and Zobel, a younger Ingersoll has been added. This revision of the earlier *Theory of Heat Conduction* is a teachable text. The authors' statement that "the only mathematical prerequisite necessary for reading it is a reasonable knowledge of the calculus" seems to be entirely justified. In fact, a considerable portion of the book is careful exposition of mathematical method. This is, in fact, a good text on the Fourier conduction equation, Fourier series, and Bessel functions.

Each chapter ends with a collection of problems to which answers are given. Graphic presentation is generous and well-planned. Appendixes provide values of properties and of functions necessary to applications of the methods.

Only conduction is considered. Convection and radiation appear only in an auxiliary role. The entire book is an expansion of, for example, the first two chapters of McAdams' *Heat Transmission*. It is a commendable expansion.

About 25 years ago, chemical engineers in America began to teach the engineering profession the subject of heat transfer. Both their preoccupations and their antecedents emphasized convection and radiation at the expense of conduction. To engineers, therefore, heat transfer had to do with Reynolds, Nusselt, Prandtl, and Grashof numbers and with emissivity and transmissivity. Now conduction is coming into its own once more.

The examples given by the authors are frequently drawn from the science of geology. Nevertheless, many engineering applications are discussed. Electric welding, casting of metals, cooling of concrete dams, and heat sources for heat pumps are among the engineering topics discussed.

A chapter is devoted to "Auxiliary Methods of Treating Heat-Conduction Problems." These include the method of isothermal surfaces and flow lines, electrical methods (electrical analogy), solutions from tables and curves, the Schmidt method, the relaxation method, and what the authors call the step method. The book ends with a chapter on "Methods of Measuring Thermal-Conductivity Constants."

PROF. JOSEPH H. KEENAN
Department of Mechanical Engineering
Massachusetts Institute of Technology

Aircraft Basic Science

By the Technical Development Staff of Northrop Aeronautical Institute. Charles Edward Chapel, Chief Editor. New York, McGraw-Hill Book Co., Inc., 1948. 440 pp., illus., diagrs. $6.00.

In general this book has attempted to present a coverage of interesting basic information for use by those desiring to become aircraft and aircraft engine mechanics. It is written in

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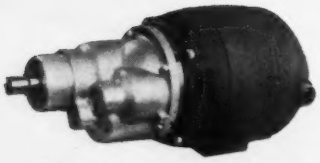

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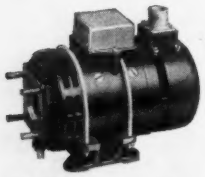

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simple understandable language supplemented by some excellent illustrations.

It covers in an interesting manner the simple principles of theory of flight with the objective of being informative without going into too much advanced study of an engineering nature.

The structural section of the book is devoted to nomenclature dealing principally with fundamental practices and follows through a well-done description of airplane parts, particularly as they pertain to light aircraft.

The phase of the book concerning blueprint reading is brief, being restricted to simple fundamentals and it is evidentally intended as an introduction rather than a complete coverage of blueprint reading as it is usually taught to advanced aircraft and engine mechanic students.

The section concerning plumbing is presented clearly and is practical. It again deals with fundamental practices in a general manner, making it easy to grasp and offering a good foundation for further study in this field.

The chapters concerning electrical theory and various electrical components used in aircraft is by far the major portion of the book and involves a considerable amount of detail. It presents fundamentals and principles in an understandable manner providing a continuity of theory into its practical application in such things as generators, motors, and other electrical components. Brief trouble-shooting charts add to the value of this section. Further discussion concerning the application of electronics to the present-day airplane would have added to this phase of the book.

The instrument section covers the usual descriptive matter concerning different types of instruments as to their theory of operation and includes a review of basic troubles in these instruments.

It is understood that this text is the first of a series of three in which the other two cover *Aircraft Power Plants* and *Aircraft Maintenance and Repair*. It is possible that these other texts are intended to have considerably more detail. It is to be stressed that *Aircraft Basic Science* seems to be intended for general information rather than a complete coverage of data that would be needed by aircraft and aircraft engine mechanics. Used as a text to present initial approaches to aviation mechanics in an understandable form, this book can be recommended as good introductory reading matter.

C. S. (CASEY) JONES
President
Academy of Aeronautics, Inc.

Aircraft Power Plants

By The Technical Development Staff of Northrop Aeronautical Institute. Charles Edward Chapel, Chief Editor. New York, McGraw-Hill Book Co., Inc., 1948. 378 pp., illus. $6.00.

Aircraft Power Plants is not only a textbook suitable for home study and for school use but is also a work of much practical value to men engaged in the servicing and maintenance of aircraft engines. It is a companion volume to *Aircraft Basic Science* and *Aircraft Maintenance and Repair*, also prepared by the staff of the Northrop Aeronautical Institute.

Subjects treated include: Engine Principles, Classification and Nomenclature; Carburetor, Superchargers, Fuel and Induction Systems; Ignition and Starting; Valve Mechanisms and Timing; Engine Controls; Lubrication; Propellers; and Jet Propulsion.

Principles underlying operation of power-plant units are treated in considerable detail and with a minimum of formulas. The explanations are clearly stated and are well illustrated by line drawings and photographs.

The book includes much practical information concerning installation, operation, and maintenance of aircraft engines and has several excellent trouble-shooting sections. Three chapters are devoted to propeller fundamentals and to the inspection and repair of metal and wooden blades.

Considerable information is presented concerning the rapidly developing field of jet propulsion, and detailed descriptions of the General Electric Company's Type T-40 jet-propulsion turbine and of the Westinghouse 19 B Yankee turbojet engine are given.

CHARLES C. GREENE
Aeronautics Teacher
Board of Education
City of New York

Book Notes

COMFORTIZATION

Handbook of Refrigerating Engineering. 3rd Ed. W. R. Woolrich and Luis H. Bartlett. New York, D. Van Nostrand Co., Inc., 1948. 730 pp., illus., diagrs. $8.50.

This edition of a reference book last revised in 1938 contains over 300 new pages and has been completely revised. New material rejects such developments as the use of chlorine- and fluorine-substituted hydrocarbon primary refrigerants, centrifugal compressors, new uses for the absorption system, automatic controls, the use of multistage compression to attain low temperatures on a large scale, and improved welded pipe joints and soldered tubing connectors. The authors are, respectively, Dean of Engineering at the University of Texas and Director of the Engineering Experiment Station at Louisiana State University.

ENGINEERING PRACTICES & AIDS

Mechanical Drawing. Thomas E. French and Carl L. Svensen. 5th Ed., Rev. and Enl. New York, McGraw-Hill Book Co., Inc., 1948. 437 pp., illus., diagrs. $2.80.

The last previous edition of this standard book was published in 1940. New chapters have been added on Production Drawing, Aircraft Drawing, and Welding Drawings. The text has been rewritten, and new problems and illustrations have been added. The various chapters are correlated with various instructional motion pictures and film strips, and a list of these and other teaching aids is included in an appendix, with reference tables.

The Presentation of Technical Information. Reginald O. Kapp. London, Constable & Co., Ltd., 1948. 147 pp. 6*s*.

The author presented the material in this book in a series of four lectures at the University College, London, and later in the Lecture Theatre of the Institution of Electrical Engineers. The discussion centers on functional exposition, designed to present information new to the reader or listener but presented in a stimulating and lucid manner. The author's presentation is a model of what he is writing. Typical of the 15 chapters are those on The Work Done by the Person Addressed, The Proper Pace, What It Is About, Making It Easy to Understand, Making It Easy to Remember, On Meaning What You Say Generalisations, Metaphor, and Words.

MATERIALS

Engineering Materials. 2nd Ed. Alfred H. White. New York, McGraw-Hill Book Co., Inc., 1948. 686 pp., illus., diagrs. $6.00.

This new edition of a textbook for engineering students first published in 1939 contains over 125 new pages and has been revised throughout. Revisions include rewritten chapters on alloy steels and light metals and extensive additions of new material on wood, plywood, and other laminates, and protective coatings. New references are given in most bibliographies at the ends of chapters.

OPERATIONS, COMMERCIAL

University Courses in Air Transportation. Donald F. Mulvihill. University, Alabama, University of Alabama, Bureau of Business Research, 1948. 36 pp., $0.50.

The results are presented of a survey of 58 universities, for the academic year 1947–1948, which have separate schools or departments of business, to discover the extent of courses in the economics and management side of air transportation. A previous study covering the academic year 1945–1946 was published in 1947. Of the 58 universities, 29 offer one or more courses in air transportation as against 23 in 1945–1946. Of these 29, more than one course is offered by 14.

POWER PLANTS

Automobile and Aircraft Engines. Vol. 1. The Mechanics of Petrol and Diesel Engines Author W. Judge. 4th Ed., Rev. and Enl. New York, Pitman Publishing Corp., 1947. 307 pp., illus., diagrs. $6.00.

The last edition of this standard work appeared in one volume in 1930. The present first volume of a two-volume revision includes new sections on engine vibrations, engine mountings, torsional vibrations, balancing of rotating members, modern balancing machines, and valve cams and followers. The chapters on piston displacement, velocity, and acceleration; engine torque and torque diagrams; torsional oscillations; and engine balancing have been considerably revised and rewritten.

Lubrication Systems for High Altitude Aircraft. P. H. Schweitzer and David J. Gildea. (Pennsylvania State College, Engineering Experiment Station, Bulletin No. 57.) State College, Pa., 1948. 99 pp., illus., diagrs. $1.00.

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This report covers an investigation of the performance of a standard Air Force aircraft oil system with the addition of a simple deaerator on a bench test stand capable of simulating altitudes up to 55,000 ft. The addition of a simple deaerator was found to be insufficient for the improvement of performance at altitude, but more powerful modifications of the oil system were found to be successful. The most successful of these, the scavenge pump, delivers the oil into a pressure type deaerator from which it flows to the cooler, through an eductor, into the pressure pump that forces it into the engine. The eductor is connected to the make-up tank. With this system the pressure-pump discharge pressure was only reduced from 95 to 80 lbs. per sq.in. atm. between sea level and 47,000 ft. altitude. Results for R-3350 reciprocating engines have been confirmed by flight tests with the B-29 airplane and lead to the possibility of application of the system to other reciprocating engines and to turbojet and turboprop engines. A principal advantage of the system is its simplicity and flexibility, since the deaerator and eductor are both light, sturdy, and inexpensive, and the system permits unusual freedom in the placement of the oil tanks with regard to head and distance.

Steam Turbine Theory and Practice. 5th Ed. William J. Kearton. London, Sir Isaac Pitman & Sons, Ltd.; New York, Pitman Publishing Corp., 1948. 640 pp., diagrs. $6.00.

The last complete revision of this standard book was published in 1944. In this edition the text of the 1944 edition has not been changed, but a 48-page chapter on governors and governor gears has been added, covering the fundamental principles of the centrifugal governor, the use of relays, and the characteristics of steam throttle valves.

PRODUCTION

Turning and Boring Practice. Fred H. Colvin and Frank A. Stanley. 3rd Ed. New York, McGraw-Hill Book Co., Inc., 1948. 531 pp., illus., diagrs. $4.75.

This standard work was first published in 1936. The present edition includes data published in a wartime supplement in 1943; additional data on mandrel and taper work in lathes, precision boring, and boring bars for special work; and new data on carbide tools.

Drilling and Surfacing Practice. Fred H. Colvin and Frank A. Stanley. 3rd Ed. New York, McGraw-Hill Book Co., 1948. 523 pp., illus., diagrs. $5.00.

This edition includes techniques evolved during the war years which have become a standard part of postwar practice, published in a wartime supplement in 1943. The text has been revised to incorporate major improvements in machine design and operating methods since the book was first published in 1936. These include such advances in milling practice as increased attention to cutter grinding, the selection of better cutting angles, and the trend toward the use of carbide bits instead of brazed carbide tips. Machine design changes caused by increased planing speeds, such as adoption of nonmetallic bearing surface between bed and table and changes in shop practices, have also been included.

Precision Measurement, Methods and Formulas. Jack Johnson. New York, Pitman Publishing Corp., 1948. 181 pp., diagrs. $3.00.

The author's purpose is to present methods of mathematical calculation for easier and more accurate solutions of precision tool inspection problems where the gage or instrument cannot be applied directly. This is done by solving 57 projects, such as "Checking the Relief Clearance of a Die," or "Measuring an External Dovetail," stating the purpose, general application, tools recommended, procedure, explanation, and formula used, with a numerical sample solution.

SCIENCES, GENERAL

MATHEMATICS

The Mathematical Solution of Engineering Problems. Mario G. Salvadori. With a collection of problems by Kenneth S. Miller. New York, McGraw-Hill Book Co., Inc., 1948. 245 pp., diagrs. $3.50.

The author's purpose is to offer an introductory course designed for engineering students and practicing engineers and students of mathematics, chemistry, and physics, on the engineering approach to physical problems. A knowledge of college mathematics is assumed, including the calculus, but a third of the book is a review of such fundamental concepts as numbers, variables, functions, limits, continuities, derivatives, differentials, and integrals. The five remaining chapters deal with the use of plane analytic geometry, solution of algebraic and transcendental equations, solution of systems of simultaneous linear equations, elementary functions and power series, and the Fourier series expansion and harmonic analysis. The selection of topics resulted from a survey of the mathematical needs of various courses in the Engineering and other schools at Columbia University.

A Concise History of Mathematics. Dirk J. Struik. New York, Dover Publications, Inc., 1948. 2 Vols., pp. 1–124, 125–299. $1.50 each.

As Professor Struik observes, the condensation of the history of mathematics into less than 300 pages required strict adherence to certain principles and the selection of material with emphasis on a few main ideas. The continuity and affinity of the Oriental civilizations is stressed, rather than mechanical divisions between the cultures of Egypt, Babylon, China, India, and Arabia. The distinction is made between established fact, hypothesis, and tradition, especially in Greek mathematics. The relation of commercial and engineering activities to mathematics in the Renaissance period is stressed, leading to the mastery of arithmetic and algebra by the commercial reckon masters and the use of rigor by the practical engineer according to his needs. This discussion of the ninteenth century is based on persons and schools rather than subjects. The first volume brings the history up to 1600, and the second covers the three centuries from 1600 to 1900. The principal books for further study are listed. The author is professor of mathematics at the Massachusetts Institute of Technology.

Mathematics for Technical Students. Part I. A. Geary, H. V. Lowry, and H. A. Hayden. London, Longmans, Green and Co., 1948 (1938). 313 pp., diagrs.

This volume, covering arithmetic, algebra, geometry, mensuration, and trigonometry, was first published in 1938 and has since been reprinted nine times.

THERMODYNAMICS

Introduction to Chemical Thermodynamics. 2nd Ed. Luke E. Steiner. New York, McGraw-Hill Book Co., Inc., 1948. 510 pp., diagrs. $6.00.

In this edition of a textbook first published in 1941, two chapters on the second law of thermodynamics have been rewritten in a single chapter, and the section on the calculation of thermodynamic functions from statistical methods has been expanded into a new chapter. The sections on real gases in the chapter on the application of the first law to gases have been considerably expanded. The recently published set of self-consistent constants and conversion factors, by the National Bureau of Standards, has been adopted for this edition for general uniformity in the use of constants. Other changes include revisions of tables, new tables, and problems based on recent data. The author is a professor of chemistry at Oberlin College.

Changes of Address

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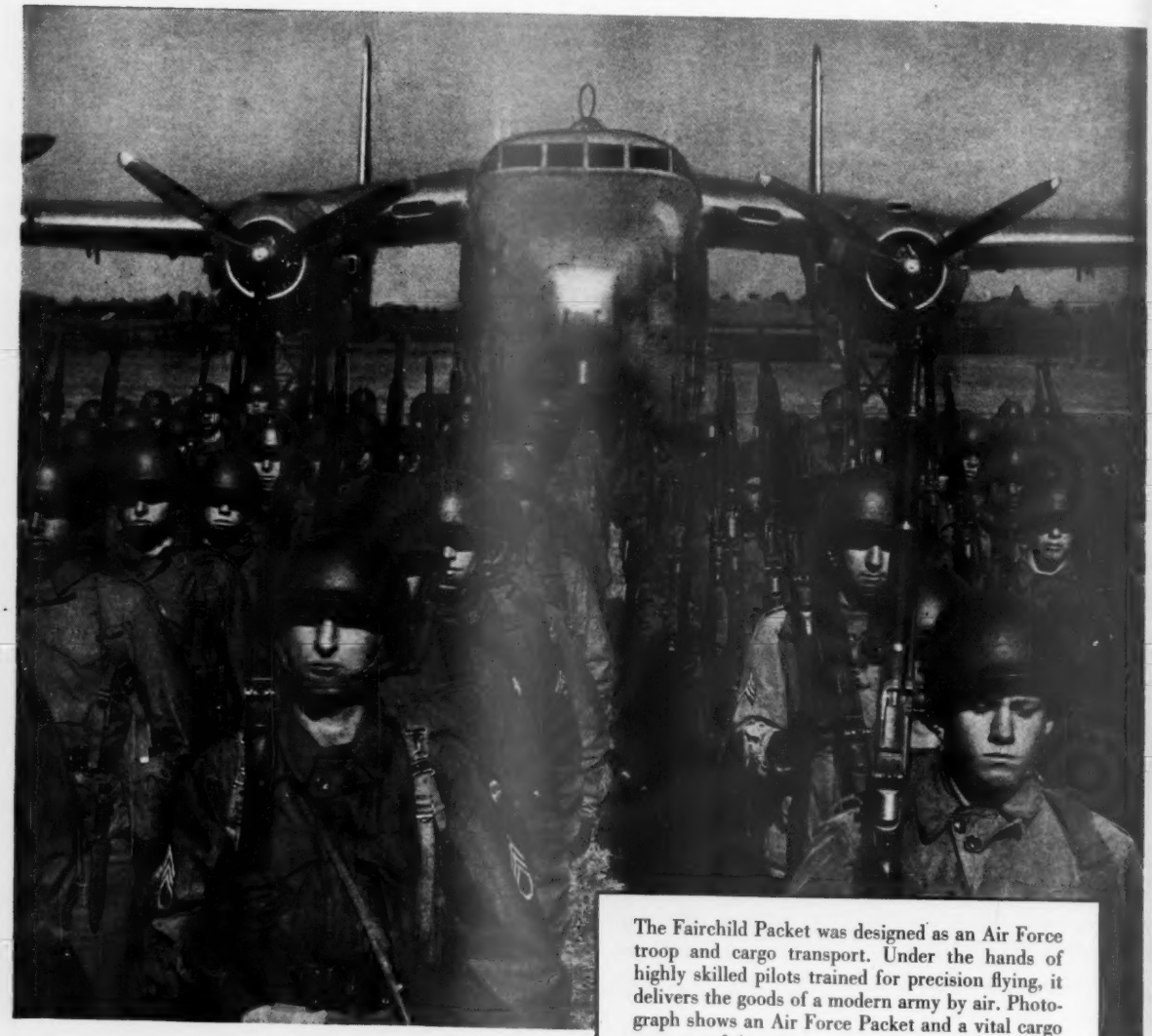

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Student Branches

(*Continued from page 15*)

University of Minnesota

Two speakers addressed the October 20 meeting—Dr. J. D. Akerman and Professor Stolarik, Head of Aeronautical Engineering Department and Professor at the University, respectively.

Dr. Akerman discussed the value in joining the I.A.S. and spoke of the Jet Testing building to be constructed by the Student Branch.

Professor Stolarik described education and research facilities in Europe, which he observed during his summer trip to England, France, and Switzerland.

New York University

New officers of the Branch are as follows: Chairman, Nathan Kotlarchyk; Vice-Chairman, Lloyd B. Lyon; Secretary, Frederick Frankel; Treasurer, Lester Kravitz. A film, *Wright Builds for Air Supremacy*, was shown at the October 14 meeting.

On November 3, R. D. Speas, Assistant to the Vice-President in Charge of Engineering, American Airlines, Inc., spoke on "What Industry Expects of the Engineer." He pointed out that the primary concern of industry with respect to engineers is technical ability. In recent years, however, cooperation with others and administrative ability have been emphasized by the war rush.

In order to better prepare themselves, students should place more emphasis on outside activities and the humanities. The importance of letter and report writing cannot be overstressed, Mr. Speas declared, since an engineer must be able to put his ideas across.

Discussing the technical aspect of engineering, Mr. Speas indicated that the aircraft industry is turning to specialists in such fields as electronics, heating and ventilation, and accommodations, instead of relying on the aeronautical engineer to design those features of the airplane wherein his knowledge is rather limited.

Northrop Aeronautical Institute

Newly elected officers were introduced at a dinner meeting held October 14 as follows: Chairman, R. Howe; Vice-Chairman, R. Nelson; Secretary, R. J. Boulanger; Treasurer, R. J. Vreeland.

James L. Straight, Western Region Manager, I.A.S., was introduced and announced that construction on the new Los Angeles I.A.S. building had begun, facilities of which would be at the disposal of the Student Branches.

Mr. Straight introduced the speaker of the evening, F. A. Cleveland, an aerodynamicist at Lockheed Aircraft Corporation. Mr. Cleveland conducted a discussion on principles of wind-tunnel supersonics. His talk was divided into several sections, the first on "Means of Motivation." This was a brief description of existing wind-tunnel types.

The next section was concerned with special instruments and calibrating devices required for accurate testing of a supersonic specimen. The speaker discussed some of the problems connected with mounting the specimens to be tested.

In conclusion, Mr. Cleveland presented a picture of the general state of the art of supersonic wind-tunnel testing.

Oregon State College

At the October 13 meeting Mark Kelly, Student Member, who has the highest scholastic standing in the Senior Class, gave a talk on "Working at Boeing." He was employed last summer at Boeing Airplane Company in Seattle in the drafting and model department.

One of his duties was to plot data calculated by the aerodynamic crew. The basic model of a plane was drawn by the model design engineers and built at the plant shop. The 8-ft. models were constructed of mahogany and steel, costing about $50,000.

The balance system of the wind tunnel employs the use of a photo-electric cell. The forces are measured by the amount of electric current required to keep the system in balance. A scale model of the large tunnel exists in which preliminary tests are made. By experimenting with this tunnel, it was discovered that shock waves were reduced if slots existed in the tunnel cross-section, Kelly said.

Chief speaker at the October 27 meeting was Dr. Cottingham who showed a series of films on *The Story of the Helicopter*, *Northrop All-Wing Aircraft*, *Bell Helicopter*, and others.

Chairman Curt Privett presided at the meetings.

Parks College of Aeronautical Technology

Chairman Frank Steinke opened the meeting of October 14 and welcomed new members present.

Two speakers from McDonnell Aircraft Corporation were present, giving talks on the "Banshee" and the helicopter "Little Henry."

Thomas Horeff, a Parks graduate, now in the Flight Test Department at McDonnell, spoke about the "Banshee" jet fighter, while Lloyd Schroeder told the members about the ram-jet helicopter. Some interesting points brought out were the differences between pulse-jets and ram-jets.

Polytechnic Institute of Brooklyn

At the October 12 meeting, Dr. N. J. Hoff, Professor of Aeronautical Engineering, discussed the services of the I.A.S. He mentioned the magnificent research library at the Institute Building in Manhattan and urged aeronautics majors to use the facilities of this library.

Rensselaer Polytechnic Institute

Willard R. Custer, inventor of the channel wing aircraft, spoke at the November 4 meeting, explaining the reasons why his invention behaves as it does.

Whereas the conventional wing creates a pressure differential over the top and bottom surfaces of only 10 per cent, he said, his channel wing induces six times that by moving air over the top surface while the underflow is practically nil.

Such tremendous lift forces are created that it is possible to take off in 15 ft.—almost vertically—and land in like manner.

To obtain rudder control (the plane has none), the r.p.m. of the engines is varied, reducing or increasing the lift on either wing.

University of Southern California College Of Aeronautics

James L. Straight, I.A.S. Western Region Manager, gave a short introductory talk at the October 20 meeting on present and future facilities available for I.A.S. members on the West Coast. Following Mr. Straight, Willis Hawkins, Chief Preliminary Design Engineer at Lockheed Aircraft, spoke on "Preliminary Design Procedures."

Spartan College of Aeronautical Engineering

With Chairman George Marz presiding, Martin Saslaw, Faculty Advisor, spoke at the October 14 meeting, making three proposals for the betterment of the I.A.S. Branch. The proposals were: (1) to discuss each issue of the JOURNAL OF THE AERONAUTICAL SCIENCES and the AERONAUTICAL ENGINEERING REVIEW, the purpose being to bring to the attention of each member material

that may be of paramount interest in his studies; (2) to have the Branch sponsor the graduation exercises; and (3) to urge members to attend some meetings of the Engineers Club of Tulsa. All three proposals were voted on favorably, and committees were organized to carry out the program.

Stanford University

New officers elected at the October 28 meeting included: Chairman, Wendell P. Garton; Vice-Chairman, Rex E. McConnelly, and Jerry F. Todd, Secretary-Treasurer. A Program Committee consisting of Wendell Garton, Robert Clark, and Carrol Morris was elected.

On November 3 the members made a field trip to the Naval Air Station at Moffett Field, where they saw a film on *The Ground Control Approach System*, and listened to aircraft being talked in by GCA units.

Syracuse University

Plans for a Library in the Aeronautical Building were discussed at the October 20 meeting, Richard Klock, Chairman, presiding. It was felt that the library would be of great practical use to the students.

University of Toronto

"The Art of Gliding and Soaring" was the subject on October 25 of a talk by Jack Ames, Stress Analyst, de Havilland Aircraft Company (Canada), who discussed both the pleasures and the problems of gliding. In addition, he showed a colored film of flights taken by the Toronto Gliding Club.

A paper was presented on "Static Testing of Aircraft Structures" by D. R. Buckingham, Student Member in fourth year Aeronautical Engineering. The paper presented a comparison of the methods employed in Great Britain, the United States, and Canada for static testing of aircraft structures and components.

Tri-State College

At the November 10 meeting, Harry Roland announced that progress had been made on the "V-Tail Project" and that a full report on both this and the "Channel Wing Project" will be submitted to the Institute when completed.

Edward Klein, a Student Member, gave a talk on the organization of an aircraft company. A film, *Aluminum Fabrication Processes*, was held prior to the meeting.

University of Wichita

Harold E. Bangerter, pilot of No. 42 midget racer designed by the Senior Class of 1947–1948 for the National Air Races last year, gave a talk on "Racing Midget Airplanes."

The plane, designed and built at the University by Bill Leighnor and flown by Bangerter, was said by the speaker to have the best turning ability and stability of any entry in the races.

News of Members

(*Continued from page 17*)

Theodore Romans resigned as Lead Layout Draftsman, Chance Vought Aircraft, to accept position of Project Engineer with Green Hydraulics, Inc., Brooklyn, N.Y.

Donald H. Sandler resigned his position at Pilotless Plane Division, Fairchild Engine and Airplane Corporation to take charge of Liaison Engineering on guided missiles at McDonnell Aircraft, St. Louis.

F. Robert Schmidt is at University of Illinois working for an M.S. in aeronautical engineering.

C. R. Smith, Chairman of the Board, American Airlines, Inc., told National Foreign Trade Council in New York that this country requires a national program to assure that national systems of transportation are maintained in a vigorous, healthy, alert condition and that transportation facilities are geared to potential requirements of "M" Day.

George P. Stevens is with Lockheed Aircraft Corporation as Stress Analyst.

Reagan C. Stunkel, President of Aviation Maintenance Corporation, has announced that work by the firm has been resumed, following a 6-month period on a "stand-by basis" to revamp company's cost structure. First contracts are with Aerovias Guest, a Mexican air line; Air Ceylon; and Pacific Northern Airlines, totaling about $300,000, for conversion and overhaul of five DC-4 aircraft.

R. L. Thoren, Division Engineer—Flight Test, Lockheed Aircraft, believes less use will be made of turboprop power plants than commonly thought. Speaking at S.A.E. meeting in Los Angeles, Thoren said 1955 transport would be straight jet.

Juan T. Trippe, President, Pan American World Airways System, speaking before American Tariff League, called U.S. foreign trade "artificial." Increased foreign travel, said Trippe, is one major means of closing gap in balance of payments between U.S. and foreign nations.

Bernard F. Twomey, Jr., who was Flight Instructor with Lincoln Flying Service, Inc., Lincoln, Ill., now is Construction Superintendent and Engineer with J. F. Powers Company.

Kenneth R. Wetmore, formerly Research Assistant, Wright Brothers Wind Tunnel, M.I.T., is now Assistant Engineer, Bethlehem Steel Corporation.

Theodore W. Wilkins has returned to the States from Buenos Aires, where he was Flight Engineer with Flota Area Mercante Argentina (FAMA), and is now Foreman at the Lockheed Aircraft Service base at Sayville, Long Island, N.Y.

Allen O. Whipple, Jr., left Chance Vought Aircraft Division and is now with Civil Air Transport, Washington, D.C.

Dr. George F. Wislicenus is Chairman of the Department of Mechanical Engineering, The Johns Hopkins University. He was Engineer in Charge of Design & Research, Aircraft Engine Division, Packard Motor Car Company, Toledo.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Bage, Arthur A., Chief Designer, Percival Aircraft, Ltd. (England).

Ferri, Antonio, Dr. of M.E. & E.E. Aero. Research Scientist P-7, N.A.C.A. (Langley Field).

Keirn, Donald John, M.S. in Ae.E., Col., U.S.A.F., Chief, Power Branch, Div. of Military App., Atomic Energy Commission (Washington, D.C.).

Transferred to Associate Fellow Grade

Desmond, Gerald Leroy, B.S., Asst. Head, Aerodynamics and Hydrodynamics Branch, Design Elements Div., Bureau of Aeronautics, Navy Dept.

Stevens, Robert Munger, M.S. in Engineering (Aero.), Head of Preliminary Design Section, Engineering Dept., Airplane Div., Curtiss-Wright Corp.

Wilkinson, Paul Howard, Editor & Publisher, *Aircraft Engines of the World.*

Elected to MEMBER Grade

Adler, Abraham C., B.S. in M.E., Aerodynamicist, Kellett Aircraft Corp.

Brown, Edward I., B.S., Aerodynamicist and Thermodynamicist, Preliminary Design Section, Turbodyne Corp.

Brown, Monroe Reyner, M.A. in M.E., Executive Secretary, Helicopter Council, Aircraft Industries Assoc.

Forisch, Edward Joseph, B.S. in M.E., Installation Engineer, Airsupply Co., Div. of The Garrett Corp.

Fullum, Richard Joseph, Jr., B. of Ae.E., Sales Engineer, Steel Sales Corp.

Gillespie, James M., B.S., Asst. to President, Garrett Corp.

Goodman, Stanley, B.S. in Physics, Physicist (Mechanics), Dept. of Commerce, National Bureau of Standards.

Herrmann, Karl L., M.E. & E.E., Manager, Herrmann Engineering Co.

Konet, Henry, B.S. in E.E., Sr. Engineer in Charge of Gyro Engineering Dept., Eclipse-Pioneer Div., Bendix Aviation Corp.

La Costa, Nicholas Joseph, Design Specialist and Administrative Asst. to Chief of Power Plant Design, The Glenn L. Martin Co.

Lobbett, James Watson, Stress Analyst "A," Ryan Aeronautical Corp.

Logan, Joseph G., Jr., B.S., Physicist Aerodynamics Dept., Cornell Aero. Lab.

Mansur, Frank, Sc.B. in E.E., Engineering Asst. to the Vice-President, Commercial Dept., Hazeltine Electronics Corp.

Moffitt, John Vincent, B.S. in Ae.E., Experimental Test Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Pai, Shih-I., Ph.D., Prof. in Aerodynamics, Aeronautical Engineering Dept., National Central University (China); Post-Doctorate Fellow, Graduate School of Aero. Engineering, Cornell University.

Petruccione, Anthony F., B.S.M.E., Mech. Engineer, Aero. Engine Lab., Naval Air Experimental Station (Philadelphia).

Porter, Robert Gordon, M.S. in Ae.E., Research Engineer, Controls Group, Pilotless Aircraft Section, The Glenn L. Martin Co.

Rea, James B., Sc.D., Research Engineer and Test Pilot, Douglas Aircraft Co., Inc.

Rosenthal, Louis W., Chief Weight Engineer, Saunders Roe, Ltd.

Sammons, Herbert F., Sales Engineer and Consultant, Haynes Stellite Co.

Sen Gupta, Sudhir Ranjan, Ph.D. Deputy Educational Adviser to Govt. of India, Ministry of Education (New Delhi).

Thiel, Adolf Karl, Dipl. Ing., Scientist, Ordnance Research & Development Div., War Department (Ft. Bliss).

Tyler, Ronald Anthony, B.Sc., Asst. Research Engineer, Gas Dynamics Dept., Div. of Mechanical Engineering, National Research Council of Canada.

Transferred to MEMBER Grade

Boteler, Earl W., Ae.E., Aerodynamicist, Pilotless Aircraft, Bureau of Aeronautics, Navy Dept.

Corrsin, Stanley, Ph.D., Asst. Prof. in Aeronautics, The Johns Hopkins University.

Dailey, Vance C., B. of Ae.E., Aeronautical Engineer—Aerodynamics, Naval Air Development Station (Johnsville, Pa.), Navy Dept.

Graham, Frank Dunstan, M.S.E., Assoc. Flight Test Engineer, Cornell Aero. Lab.

Jones, Arthur L., B. of Ae.E., Aero. Research Scientist, Ames Aero Lab., N.A.C.A. (Moffett Field).

Kahane, Abraham, M.S. in Engineering, Research Assoc., Aero. Lab., Princeton University.

Landis, Raymond Bruce, Design, Engineer, Rotawings Div., The Glenn L. Martin Co.

Morduchow, Morris, Dr. of Ae.E., Instructor of Aero. Engineering, Polytechnic Institute of Brooklyn.

Moyer, John C., B.S., Aero. Engineer, Engineering Design Div., Naval Air Material Center, U.S. Naval Base Station (Pa.).

Perkinson, Robert Edward, B.Ae.E., Aerodynamicist, McDonnell Aircraft Corp.

Stein, Hyman, M. of Ae.E., Sr. Aerodynamicist, Aerodynamics Group, Development Section, Republic Aviation Corp.

Stein, Manuel, B.S. in M.E. (Aero.), Aero. Research Scientist, N.A.C.A. (Langley Field).

Tobey, Harry, M.Sc. in M.E., Asst. Chief of Stress, Piasecki Helicopter Corp.

Tribus, Myron, B.S., Research Engineer and Instructor in Thermodynamics, University of California.

Whittaker, James Robert, B. of Ae.E., Ordnance Aerodynamicist & Research Engineer, U.S. Naval Ordnance Lab. (Washington, D.C.).

Williams, Max L., Jr., Ae.E., Lecturer, California Institute of Technology.

Elected to Associate Member Grade

Roberts, Gordon M., Technical Librarian, Ranger Aircraft Engines Div., Fairchild Engine and Airplane Corp.

Short, Vaun Gray, Airport Control Officer and Naval Aviator, U.S.N.A.S. (Moffett Field).

Strickland, Jasper Dobbins, Registrar, Aero. Engineering & Mechanics School, Cal-Aero Technical Institute.

Whytlaw, John Gilkison, Col., U.S.A.F.; Air Force Liaison Officer, First Army.

Transferred to Associate Member Grade

Dudek, Edward Frank, Jr., B.S., Instructor in Engineering Mechanics, University of Nebraska.

Elected to Technical Member Grade

Cordner, Clyde A., Design Engineer, Ryan Aeronautical Co.

de Koningh, Gerrit, Ingenieur, Delft University, Technical Staff, Royal Netherland Army.

Fukushima, Toshiyuki, Design Draftsman, Piasecki Helicopter Corp.

Leatherbury, Clifton H., Jr., M.S., Project Engineer, Aeronautics Dept., David Taylor Model Basin, Navy Dept.

Lopez, Tomas, M. of Ae.E., Capt., Engineer's Branch, Chilean Air Force.

Rejante, Cesar V., Aero. Engineer, Philippine Air Lines, Inc.

Sherts, William M., M.S. in Ae.E., Sr. Engineer, Curtiss-Wright Corp. (Columbus).

Smith, Robert Douglas, M.S.M.E., Mechanical Engineer, Aircraft Gas Turbine Engineering Div., General Electric Co.

Weinshanker, Hyman, B.S. in Physics, Research Physicist, N.A.C.A. (Cleveland).

Yanquez, Mauricio, M. of Ae.E., Capt., Engineer's Branch, Chilean Air Force.

Transferred to Technical Member Grade

Aker, John Robert.

Alden, William Arnold, B.S. in Ae.E., Mathematician "A," Douglas Aircraft Co., Inc. (Santa Monica).

Armintrout, Charles L., Engineering Draftsman, Lockheed Aircraft Corp.

Athen, Adolph John, B. of Ae.E., Graduate Student and Research Asst., Polytechnic Institute of Brooklyn.

Atkinson, Walter Charles, Lt. U.S.A.F.; Project Engineer, Armament Lab., Wright-Patterson Air Force Base.

Beckelman, Jack D., B.S. in Ae.E. Major, U.S.A.F.; Military Engineer and Sr. Pilot, Research & Development Branch, AT/M & S, M.A.T.S. (Gravelly Point, Va.).

Bell, Robert Edward, B.S. in M.E., Lt., Pilot, U.S.A.F.

Boscarello, Frank, Tool Engineer, Grumman Aircraft Engineering Corp.

Braceland, Hugh V., B.S. (Aero.), Sr. Engineer, Trans-Canada Airlines.

Brown, Marvin Marshall, B.S. in M.E., Jr. Engineer, Youngstown Sheet & Tube Co.

Brunk, James E., B.S., Aerodynamicist, North American Aviation, Inc.

Bush, Frederick E., Capt., Pilot, U.S.A.F.; Air Technical Intelligence Officer, Wright-Patterson Air Force Base.

Cameron, Robert James, Lt., U.S.A.F.; Pilot, Scott Air Force Base, Ill.

Cline, Maurice D., B.S. in Air Transportation, Asst. Airport Manager, Board of Aviation Commissioners, Evansville Municipal Airport.

Costilow, Eleanor Louise, B.S. Ae.E., Research Fellow, Purdue University.

Couberly, John N., B.S. in Ae.E., Mathematician "A," Douglas Aircraft Co., Inc. (El Segundo).

Cox, Carl B., M.S. in Ae.E., Aerodynamicist "A," Boeing Airplane Co. (Seattle).

Cox, William Ralston, B.S. Ae.E., Jr. Stress Analyst, Goodyear Aircraft Corp.

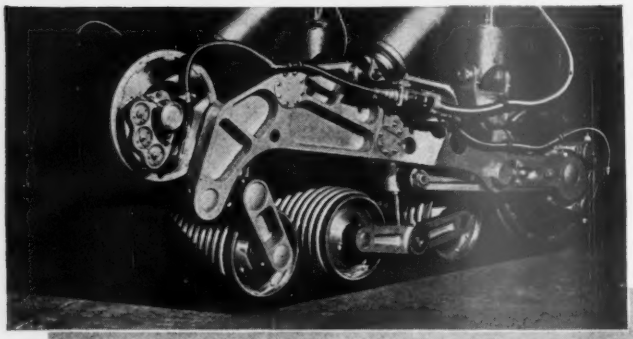
Cunningham, Alexander Arthur, B.S. in Ae.E., Mathematician "A," Douglas Aircraft Co., Inc. (El Segundo).

Davidson, Harold Wm., B. of Ae.E., Student, California Institute of Technology.

Eagan, Jerry A., A.A., Detail Designer, McDonnell Aircraft Corp.

Evans, Margaret I., B.S. in Ae.E.

Farley David H., B.S. in Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).



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Forrette, Robert Eugene, B.S. in Ae.E., Aero. Research Engineer P-1, Lewis Flight Propulsion Lab., N.A.C.A. (Cleveland).

Fuchs, Alfred Louis, Jr.

Gardiner, Lester Arthur, B.S.

Garrett, Charles, Jr., B.S. in Ae.E., Flight Test Engineer, McDonnell Aircraft Corp.

Gaudiani, Vincent A., B.S., Major, Pilot, U.S.A.F.; Graduate Student in Industrial Engineering, Columbia University.

Grodson, Anthony George, B.S. Ae.E., Aero. Engineer, Aerodex, Inc.

Guggedahl, John Albert, B.S. in Ae.E., Test Engineer (Trainee), General Electric Co.

Henderson, James Henry, B.S. in A.E., Aero Engineer, Langley Aero. Lab., N.A.C.A.

Hoche, Herbert Albert, Jr., Draftsman "B," Lockheed Aircraft Corp.

Howell, Carrol Leon, B.S.M.E., Research and Development Engineer, Phillips Petroleum Co.

Hume, William Haywood, B.S., Capt., Pilot, U.S.A.F.; Project Engineer and Liaison Officer; Air Materiel Command, Engineering Field Office, Navy Department (Washington, D.C.).

Hummel, K. Harold, B.S. in Ae.E., Stress Analyst "B," Boeing Airplane Co. (Seattle).

Johnson, Aldie E., Jr., B.S. in Ae.E., Aero. Research Engineer, Structures Research Div., N.A.C.A. (Langley Field).

Johnson, Donald F., M. of Ae.E., Aero Research Scientist, N.A.C.A. (Cleveland).

Katsanis, Theodore, B.S. in Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Klotz, Robert Andrew, A.A. in Ae.E., Student, Tri-State College.

Kosciuch, Benjamin.

Kozloff, Alexis V., B. of Ae.E., Aero. Engineer, North American Aviation, Inc.

Lamorte, Donald John, B.S.A.E.

Lavars, Paul Alfred, B.E. in M.E. (Aero.), Lt. Comdr., U.S.N.R.; Commanding Officer, CVEG78, Naval Air Station (Los Alamitos).

Lawrence, Alvin Andrew, B.S., Graduate Student, Indiana Technical College.

Ledford, Otto C., B.S. in Ae.E., Major, U.S.A.F.; Sr. Pilot and Asst. to Director of Research and Development, A.M.C., Wright-Patterson Air Force Base.

Lepore, Raymond Rocco, Designer, Goodyear Aircraft Corp.

Lindberg, John W., B.S. in Ae.E., Design Engineer, Boeing Airplane Co. (Seattle).

Lindell, Keith Gordon, B.S., Major, U.S.A.F.; Pilot, Flight & Squadron Comdr. (Washington, D.C.).

Lindsay, Russell Chester, B.S. Ae.E., Sr. Draftsman, Goodyear Aircraft Corp.

Mark, Leon, B.S. in Ae.E., Wind Tunnel Engineer, U.S. Govt. (Wright Field).

Mason, Homer Paul, B.S. in Ae.E., Student, Mechanical Engineering, Alabama Polytechnic Institute.

McFall, John Claude, B.S. in Ae.E., Aero. Engineer, N.A.C.A. (Langley Field).

McReynolds, John George, Jr., B. of Ae.E., Jr. Aerodynamicist, McDonnell Aircraft Corp.

Morris, Marshall M., B.S., Jr. Engineer "B," Master Layout, Body Group, Boeing Airplane Co. (Seattle).

Moul, Martin Thomas, B. of Ae.E., Aero Research Scientist, N.A.C.A. (Langley Field).

Nason, Curtis H.

Nathan, Robert Leroy, B.S. Ae.E., Aero. Research, Design, and Development Engineer, Wright-Patterson Air Force Base.

Newton, Earl Brook, B.S., 1st Lt., Pilot, U.S.A.F. (Randolph Field).

Pedersen, Douglas Patton, B.E., Lt., Base Engineering Officer, 61st Fighter Wing, California Air National Guard.

Peterson, Max A., A.A. in Ae.E., Engineering Draftsman, Northrop Aircraft, Inc.

Picchiello, Michael Vincent, Detail Draftsman, Hydraulics and Controls Group, Republic Aviation Corp.

Plato, Russell John, B.E., Engineering Designer "B," Douglas Aircraft Co., Inc. (El Segundo).

Polovkas, Vincent George, B.S. in Ae.E., Instructor, Department of Aero. Engineering, University of Florida.

Poplawski, Henry R., B. of Engrg., Technical Supervisor, The Glenn L. Martin Co.

Pospisil, Frank, B.S. in M.E. (Aero.), Draftsman "A," Douglas Aircraft Co., Inc. (Santa Monica).

Rentmeester, Lester F., Capt., U.S.A.F.; Research and Development Engineer, Pilot, Hq., A.M.C., Wright-Patterson Air Force Base.

Rice, Joseph A., B. of Ae.E., Apprentice Engineer, Static Test Lab., Grumman Aircraft Engineering Corp.

Richardson, Harry L., B.S. Ae.E., Jr. Engineer, Wright Aero. Corp.

Rickert, Walter K., Capt., U.S.A.F.; Air Officer and Pilot, Air Institute of Technology (Wright-Patterson Air Force Base).

Rizika, Jack Wilford, B.S. in Ae.E., Research Appointee to Academic Staff, Project Meteor, Massachusetts Institute of Technology.

Rogers, Arthur William, B. of Ae.E., Graduate Student, Brooklyn Polytechnic Institute.

Rossello, Dante, B.S. in Ae.E.

Ruick, Robert H., A.A., Capt., U.S.A.F.; Design and Development Officer, McClellan A.F.B. (California).

Ryding, Herbert C., B.S. in Ae.E.

Serafin, Walter T., B.Ae.E.

Serafini, John S., B. of Ae.E., Aero. Research Scientist P-2, Lewis Flight Propulsion Lab., N.A.C.A.

Shaw, James Robert, B.S. in Ae.E., Jr. Aerodynamics Engineer, The Glenn L. Martin Co.

Silverstein, Sidney, B. of Ae.E.

Spencer, John Oliver, B.S. in Ae.E., Lt., Navigator, U.S.A.F.

Triplett, William Charles, M.S. in Ae.E., Aero. Research Scientist P-2, Ames Aero. Lab., N.A.C.A.

Tscherfinger, William Edward, B.Ae.E., Jr. Aerodynamicist, The Glenn L. Martin Co.

Waugh, Merle, M.S., Aero. Research Scientist, Ames Aero. Lab., N.A.C.A. (Moffett Field).

Wells, Don Burnett, Engineering Draftsman "B," Northrop Aircraft, Inc.

Whitley, Robert Patrick, B.S. in Ae.E., Aero. Engineer P-1, N.A.C.A. (Langley Field).

Wintemberg, Walter M., B.S.

Woodall, Robert F., Jr., B.A.E., Asst. Aerodynamicist, McDonnell Aircraft Corp.

Woodcock, Robert James, B.S., Aero. Engineer, Lewis Flight Propulsion Lab., N.A.C.A. (Cleveland).

Wuerz, Robert Albert, Detail and Design Engineer, McDonnell Aircraft Corp.

Yarbrough, Jack Richard, B.A.E., Asst. Research Engineer, Flight Test Section, McDonnell Aircraft Corp.

Youngren, Harold L., B.S. in Air Transportation, 1st Lt., U.S.A.F. (Reserve).

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Research Engineer—For analysis of internal flow conditions and stress design of motor cases for jet propulsion devices. Five to 15 years of technical experience preferred. Jet propulsion experience helpful but not necessary. Problems involve knowledge of some thermodynamics, fluid flow, and stress analysis. This represents an opportunity with a young and rapidly growing activity. Salary offered will depend on experience. Write to: Thiokol Corporation, Elkton Division, Box 244, Elkton, Md.

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Aeronautical, Electronic, and Electrical Engineers—The Aeronautical Structures Laboratory of the Naval Air Experimental Station is seeking engineers in several fields for employment in Philadelphia, Pa. Fifteen vacancies exist for aeronautical, electrical, and electronic engineers and engineering aides. Applications are desired from persons who have had training and experience in the fields of engineering described below. Applications for the positions should be made on Standard Form 57, available at any first- or second-class post office, and should be mailed to Industrial Relations Officer, Naval Air Material Center, U.S. Naval Base Station, Philadelphia 12, Pa. **Aeronautical Engineers (Structures)**—Structural development and flight tests. Analysis of loads in aircraft components imposed by high air speeds and accelerations; static and dynamic testing of aircraft structural features; development of test equipment, methods, and procedures; analysis of data; and preparation of reports. Six P-1 grades at $2,974.80 per year and three P-2 grades at $3,727.20 per year are open. **Electrical and Electronic Engineers**—To develop, evaluate, and operate special laboratory and flight-test equipment. Includes direct and remote recording (Telemetering) equipment, the pickup instruments, such as strain gages, accelerometers, air-speed indicators, altimeters, etc. One P-1 grade at $2,974.80 per year, two P-2 grades at $3,727.20 per year, and two P-3 grades at $4,479.60 per year are open. **Engineering Aides**—Provide assistance to professional engineers performing the duties described above. Prepare sketches for laboratory test preparations. Provide liaison between laboratory and engineering offices. Record data such as strains and deflections. Make tabular calculations and prepare graphs as direct. One SP-5 position is open; salary $2,724 per year.

Electrical Engineer—To coordinate and develop electrical equipment for rocket motor projects such as ignition systems, starting, instrumentation, test equipment, interlock and limit switches; should be familiar with aircraft standards. Adress: Administrative Engineer, Rocket Department, Curtiss-Wright Corporation, Propeller Division, Caldwell, N.J.

Liaison Engineer—Basically a good designer familiar with rocket motor development to coordinate development work of staff engineers with customer and contract requirements. Address: Administrative Engineer, Rocket Department, Curtiss-Wright Corporation; Propeller Division, Caldwell, N.J.

Technical Writer—To prepare service, operation, overhaul, and similar data on rocket motors and their associated equipment. Address: Administrative Engineer, Rocket Department, Curtiss-Wright Corporation, Propeller Division, Caldwell, N.J.

Aircraft Dynamics Engineers—For research work on subsonic and supersonic flutter, vibration, dynamic loads, stability and control of supersonic missiles, and helicopter dynamic problems. Applicants must have good background in fundamentals of applied mechanics and mathematics. Advanced degree or previous experience in field is essential. Salaries commensurate with training and experience. Cornell Aeronautical Laboratory, Employment Office, 4455 Genesee St., Buffalo 21, N.Y.

Helicopter Engineer—Experience in helicopter aerodynamics and stress analysis required. Apply in writing with a résumé of experience and education to American Helicopter Company, 900 N. La Brea Ave., Inglewood, Calif.

Aircraft Engineers—Opportunities for research and development on the B-36, world's largest bomber, and other heavy aircraft, at Convair's Fort Worth, Tex., Division. Experienced engineers needed now in these classifications: Aerodynamicists, Engineering Designers, and Engineering Draftsmen. Send complete summary of training and experience to Engineering Personnel Office, Consolidated Vultee Aircraft Corporation, Fort Worth, Tex.

Structural Designers—Engineers experienced in design of sheet-metal structures desired for large cargo airoraft project. Graduate engineers preferred. All replies held confidential. Write, Project Engineer, Chase Aircraft Company, Inc., West Trenton, N.J.

Layout Draftsmen—Six or more years' experience in aircraft layout and design. Cargo aircraft experience desired. Graduate engineers preferred. All replies held confidential. Write, Project Engineer, Chase Aircraft Company, Inc., West Trenton, N.J.

Stress Analysis—Personnel with experience on sheet-metal, monocoque, cargo-type aircraft desired. Graduate engineers with 5 or more years' experience preferred. All replies held confidential. Write, Project Engineer, Chase Aircraft Company, Inc., West Trenton, N.J.

Research Aeronautical Engineer—Engineering graduate with good command of physics and mathematics, to assist in the conduct of ballistic research. Excellent opportunity to obtain research experience and advanced degree. Address reply to D. W. Dutton, Director, Daniel Guggenheim School of Aeronautics, Georgia Institute of Technology, Atlanta, Ga., giving full particulars. Salary open.

Engineers—Rotary Wing—Now engaged in C.A.A. certification. Unlimited opportunities for qualified stress analyst, flight-test engineer, detail and layout draftsmen. Opening as Chief Engineer to take charge of certification work. Write full particulars to Jensen Helicopter Company Inc., Tonasket, Wash.

Aeronautical Engineer—A position is available in the Research and Development Group of the Naval Bureau of Aeronautics in Washington, D.C., for an Aeronautical Engineer preferably with a background in electronics. Duties will involve research and development program planning and related tasks of justification presentation and analysis. Ability to express complex thought in clear readable fashion essential. This position is under Civil Service and will command a salary of $6,235 per annum. Address: Personnel Division, Bureau of Aeronautics, Department of the Navy, Washington, D.C.

Aeronautical Engineers—The U.S. Naval Air Station, Quonset Point, R.I., has announced a probational examination for Aeronautical Engineer (Power Plants) $4,479 a year, and Aeronautical Engineer (General) $4,479 to $7,432 a year. This examination will be used to fill future vacancies occurring at the Air Station and at other Federal Agencies throughout the New England states. Applications are being accepted until further notice. Write to Recorder, Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I., for further details.

Flutter Engineer—Aeronautical Engineer graduate with several years of experience in flutter and vibration problems for work on advanced military aircraft. Address reply to Engineering Personnel Office, North American Aviation, Inc., Municipal Airport, Los Angeles, Calif.

Preliminary Design Engineer—The Agricultural and Mechanical College of Texas, Department of Aeronautical Engineering, has an opening for a man to teach preliminary design and participate in aeronautical research. Facilities include large wind tunnel, excellent paved airport, and flight-research equipment. Rank and salary dependent on training and experience of applicant. Edward E. Brush, Department of Aeronautical Engineering, A. & M. College of Texas, College Station, Tex.

930. General Manager—For long-established company, near Cleveland, manufacturing both commercial and aircraft pumps for oil, fuel, air, and for water injection, also valves, etc. Management experience encompassing the direction of sales and familiarity with Navy and Air Force contract procedures and requirements are essential requisites for this position. Preferential consideration will be given if such experience is supplemented by intimate knowledge of design, manufacture, and sales of pumps. Company has good supporting organization and has maintained excellent labor relations. Outstanding prospects for a successful future for right man. Application must give complete information of past experience and management background with at least two responsible references. Also state salary requirement.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

AVAILABLE

934. Instrumentation and Liaison Engineer—Twelve years' all-around experience on experimental reciprocating type aircraft. Three and one-half years specializing on development, manufacturing, and installation of special instrumentation for experimental jet aircraft. Some experience on instrumentation on guided missiles. Desires position on West Coast or in South in related work. Single, age 29; free to travel; would consider service engineering position.

932. Engineering, Management, or Administration—B.S. in M.E. and Masters Degree in A.E. Over 20 years' experience in aircraft and missile design, manufacture, and flight test involving C.A.A., Army, and Navy. Directly responsible for design of at least eight airplanes. Detail experience includes 13 years of stress analysis, project design, testing, flight test. The last 7 years of this period supervised all of the above in capacity of chief engineer. Factory manager responsible for planning, tooling, and production for 3 years, then assistant general manager. Manager of divisions of two large corporations for the last 5 years. Desires responsible position as engineering or management executive.

931. Engineer-Lawyer—B.S. in M.E. (Aeronautical Option) in 1942. Four years' experience; 1 year in stability research in a N.A.C.A. wind tunnel; 3 years in the Navy in maintenance of aircraft and in BuAer as assistant on a design desk. Will graduate from Stanford Law School, May, 1949. Desires position in which both backgrounds will be useful. Prefers West Coast.

929. Aeronautical Engineer—Fourteen years' experience, last 10½ in aircraft design. B.S. in M.E. 1934 from Guggenheim School of Aeronautics of New York University. Has held position as designer, project engineer, chief aerodynamicist, and acting chief engineer and has been active in design of metal and wood aircraft for Navy and civil use, helicopters, and propellers. Desires responsible position requiring imagination and activity. East Coast preferred.

928. Aeronautical Operations Engineer—Just completed installation of passenger and cargo service in South America. Efficient, capable operations engineer with an outstanding record. Winterization expert and specialist on sub-zero operations. Former superintendent U.S. Air Mail. Capable of supervising flight-test operations or assuming position as assistant to busy executive. Former general manager of air line.

927. Management, Engineering Administration—Age 46, born New York; 2 years Rensselaer Polytechnic Institute; 2 years University of Virginia; special courses civilian and service schools. Approximately 9 years' aircraft construction with four aircraft concerns; 8 years' additional as naval officer assigned as the Bureau of Aeronautics Representative at three major aircraft plants. Associate Fellow I.A.S., Member A.S.C.E., Theta Tau, Rensselaer Society of Engineers, Phi Delta Theta.

926. Manufacturers Representative—Aeronautical operations engineer, highly capable sales and technical representative. Twenty-five years in aviation field. Well and favorably known to most aircraft manufacturing and aircraft operating executives. Has outstanding record in aeronautics. Recently operating in South America. Prefers Pacific Coast assignment, but will consider Eastern connection.

925. Research Associate Professor—Six years' university training as aeronautical engineer. Five years in design and production of Navy aircraft; 3 years' teaching combined with experimental research. Desires permanent position as research supervisor with graduate teaching opportunity. Special field—supersonic and transonic aerodynamics. Family housing essential.

924. Engineer—Graduate (Majors in Physics and Mathematics) of University of California. One year's graduate work in Physics. Five years' experience as a stress analyst and dynamicist in aeronautical engineering.

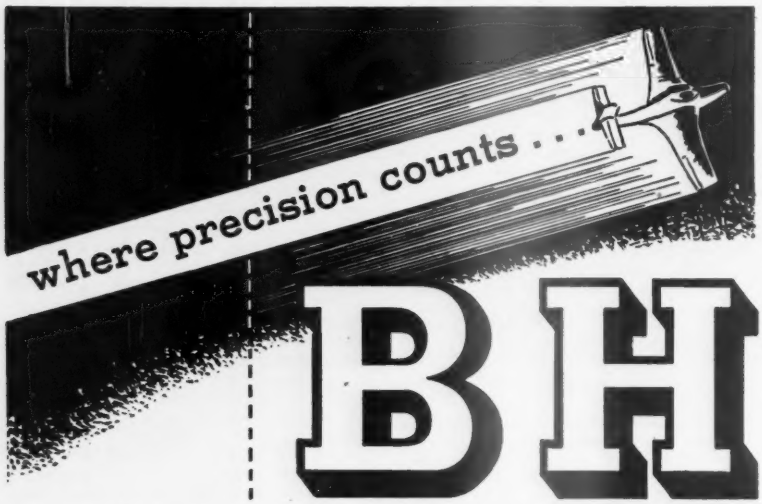
923. Writer, Technical or Advertising—Will help sell product, proposal, or idea by writing ads, booklets, promotional letters, publicity articles, or reports; will edit, ghost-write, or collaborate on technical articles. Writes technical descriptions that are easy to understand by nontechnical men. Experienced engineer, able to see things from prospect's point of view, analyze products, pick out points that appeal, and present them in manner that invites action. Full or part time. Detroit area, unless special job can be handled by mail.

922. Engineer, Sales or Administrative—B.S. in Mechanical Engineering; 32 years of age; single; 10 years' experience, of which last 6 in various aircraft engineering capacities; former officer Marine Corps aviation, licensed pilot. Will consider any offer in excess of $6,000 per annum, will furnish complete details of experience and recommendations immediately upon request.

921. Aeronautical Engineer—M.S. from University of Michigan. Five years of teaching, followed by 12 years with two companies as aerodynamics engineer. Most of experience in aerodynamic development of high-speed military aircraft and, in the past 2 years, of pilotless aircraft.

920. Aeronautical Engineer—Wind-Tunnel Assistantship and M.S. in Aeronautics, Cal Tech. Nine years' experience all phases of aerodynamics including performance, stability, flight-test, preliminary design. Specializing in wind-tunnel testing including model design, preparation of programs, testing and tunnel operation, analysis of results, and company representation for aircraft and missile projects.

919. Industrial and Aeronautical Engineer—B.S. in Mechanical and Electrical Engineering; 2 years' postgraduate aeronautical engineering.



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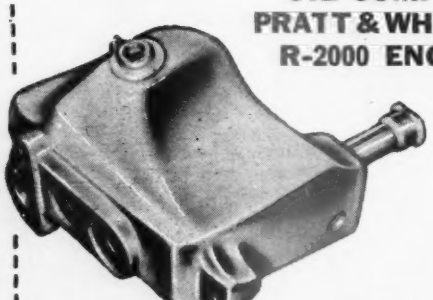

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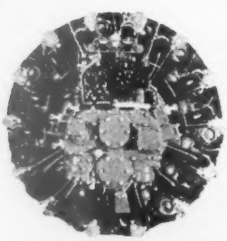

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916. Aeronautical Engineering Specialist—Age 26. Graduate engineer, mechanical major. Four years' experience government service as draftsman, design engineer in engineering, preliminary design, and design research divisions, Bureau of Aeronautics. Familiar with general design procedure. Knowledge of aviation, scientific, and naval affairs. Desires position as junior engineer; Washington representative (technical aide-engineering) for consulting engineers, research organizations, or Government contractors.

914. Flight Test Engineer—B.Ae.E. Age 32; married. Four years' experience in flight-test planning and analysis with high-performance military aircraft manufacturer. Responsible for several extensive research projects. Thoroughly familiar with the reduction of data obtained from complex automatic recording instruments.

913. Engineer—B.M.E. Graduate studies in mathematics and engineering. One year as assistant project engineer on automatic aircraft control. Two years in analysis of the dynamics of missiles and their control systems. One year in charge of design and operation of equipment employing electronic analogue computers for simulated flight test of actual missile control apparatus. One year in charge of analytic evaluation of missile guidance systems.

911. Management, Administration, or Sales—B.S. in M.E. Over 20 years' experience in aviation, including engineering, production, quality control, contacts, contract termination, materials, costs, and sales. Five years' research, N.A.C.A., hydrodynamics and aerodynamics. One year flight performance analysis. A and E mechanic; private pilot. Supervisory and administrative experience. Presently responsible for test and development of jet power plants at missile test center. Desires responsible position with young organization needing a versatile, well-informed executive. Prefers West Coast.

910. Aeronautical Engineer and Aviation Executive—Young, aggressive, responsible, full of initiative, with 15 years' experience, including 12 years aviation, 3 years nonaviation. Detailed aviation experience includes 9 years' aeronautical engineering in stress analysis, airplane structural design, testing, aerodynamics, supervision, and 3 years as top manager of aviation division (engineering and sales) of a large corporation. Also has acted as a consultant to U.S. Army Air Forces. Has actively participated in a responsible or key engineering position during the certification of eleven completed airplane projects (Army and civilian), and approximately 25 of a preliminary or partial nature. Thoroughly familiar with late Civil Aeronautics Administration Regulations in work as Assistant Chief of the Airframe and Equipment Engineering Division; B.S.M.E., University of Kansas, 1932; *Who's Who in Engineering;* and *Who's Who in Aviation.* Desires interview with responsible companies seeking top drawer engineering talent and know-how to take charge of engineering and/or management of aviation division or equivalent.

909. Physicist-Aerodynamicist-Thermodynamicist—Ten years of diverse experience in the aircraft and gas-turbine fields. Has done internationally recognized research. Desires new position, preferably on consulting basis.

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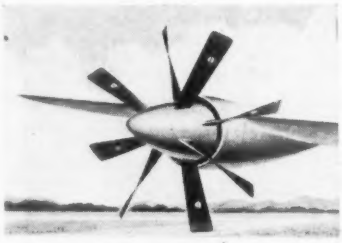

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Index to Advertisers

A

Aeroproducts Division, General Motors Corporation 90
Airborne Accessories Corporation 48
AiResearch Manufacturing Company Division, The Garrett Corporation 2
★Aluminum Company of America 70
Aviation Maintenance Corporation 60

B

Bendix Aviation Corporation, Eclipse-Pioneer Division .... Inside Back Cover
B. H. Aircraft Company, Inc. 88
Boeing Airplane Company 54
Charles Bruning Company, Inc. 74
Bunhill Publications Limited 86

C

Cal-Aero Technical Institute 86
Champion Spark Plug Company 78
Chance Vought Aircraft Division, United Aircraft Corporation 86
Clifford Manufacturing Company Division, Standard-Thomson Corporation .... Inside Front Cover
Consolidated Vultee Aircraft Corporation 69

D

Doelcam Corporation 68
Douglas Aircraft Company, Inc. 16
Dow Corning Corporation 10

E

Eaton Manufacturing Company, Valve and Saginaw Divisions 66
Eclipse-Pioneer Division, Bendix Aviation Corporation .... Inside Back Cover
Electrol Incorporated 84

F

Fairchild Engine and Airplane Corporation 80
★Fenwal Incorporated 44
★Foote Bros. Gear and Machine Corporation 58

G

G&O Manufacturing Company, The 89
Garrett Corporation, The, AiResearch Manufacturing Company Division 2
General Motors Corporation, Aeroproducts Division 90
B. F. Goodrich Company, The, Aeronautical Division 46
Goodyear Tire & Rubber Company, Aviation Products Division 1

I

Imperial Pencil Tracing Cloth, Keuffel & Esser Company 75
International Nickel Company, Inc., The 92

K

Keuffel & Esser Company, Imperial Pencil Tracing Cloth 75

L

Lamb Electric Company, The 76
Linear, Inc. 52

M

McDonnell Aircraft Corporation 86
Glenn L. Martin Company, The 72

N

North American Aviation, Inc. 86

P

Piasecki Helicopter Corporation 89

S

★Sperry Gyroscope Company, Division of The Sperry Corporation .... Back Cover, 86
Standard-Thomson Corporation, Clifford Manufacturing Company Division .... Inside Front Cover
★Surface Combustion Corporation, Aircraft-Automotive Division 62

U

United States Aviation Underwriters Incorporated 89

V

Vellumoid Company, The 86
★Vickers, Incorporated, Division of The Sperry Corporation 4

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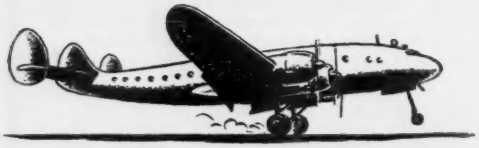

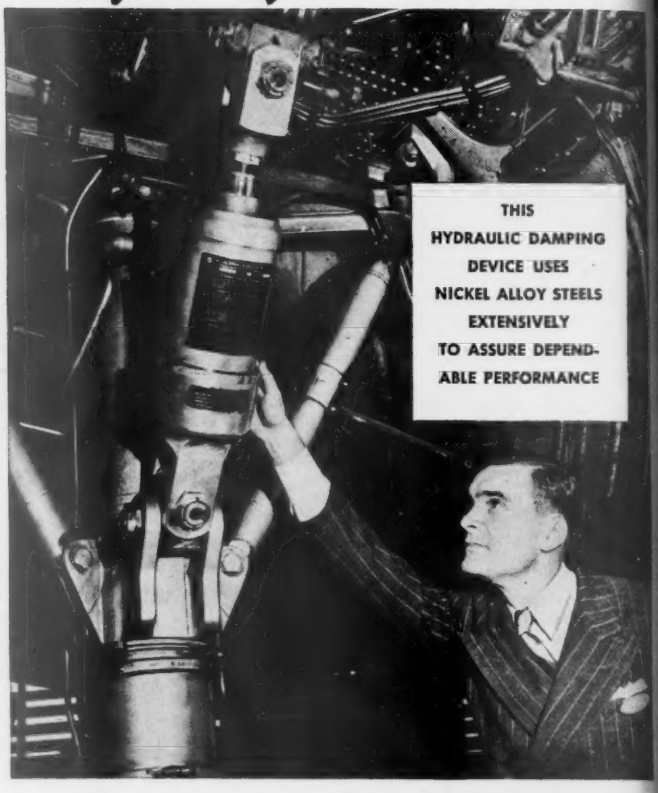

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